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Alan Dexter

IT'S A GREAT TIME TO BUILD YOUR OWN PC

SOMETHING STRANGE has just happened in the PC market. Something that bucks the trend. The decline in PC sales that we've seen since 2011 has experienced a hiccup. Just for a change, we saw a small increase for the second quarter of 2018 compared to the previous year. It's subtle, and it may not signify a major shift, but it could turn out to be the start of something bigger.

To throw some figures behind this, according to Gartner, the second quarter of 2018 saw the likes of HP, Dell, and Lenovo ship 14.51 million PCs across the United States. Compare that with the 14.26 million for the same time frame the previous year, and you're looking at growth of 1.7 percent. This is echoed to a lesser extent by the global market, which saw a 1.4 percent rise from 2Q17's 61.3m shipments up to 62.1m for 2Q18.

While this is good news for the health of the PC as a whole—and should help keep pricing in check, among other things—there's a few important things that these figures don't capture. They don't include anyone upgrading their systems, the growth in relatively niche areas—such as high-end systems and gaming PCs—and, importantly for this month's intro, machines that users have built themselves.

Building your own machine is a rite of passage for many users. Even if you later return to whole system purchases, the process of building your own rig is an invaluable exercise in terms of understanding how machines are put together. It shows you what your money actually buys, where the extra time and effort needs to be spent to turn a perfectly functional system into something you can cherish, and puts value behind any component you use. We heartily recommend building a PC at least once in your life.

This issue, we show you how to build a budget gaming system that punches well above its weight. And we do so in a level of detail that we haven't done before: Every connection, every screw, every decision, and every process is covered in intricate detail, to make sure nothing can go wrong. If you've never undertaken a system build before, this guide is for you. Alternatively, if you have a friend who could benefit from such a guide, please pass this issue on to them (once you've finished reading it yourself, of course), and see what they can produce.

The final machine is an impressive system in its own right, more than capable of handling the vast majority of common tasks. With a few choice upgrades as you go, there's no reason that it couldn't stay with you for years to come. Or, if you need more power right now, you can tweak the specification from the start, and build a PC that hits your sweet spot straight away.

On a final note, if you have any tips or experiences you'd like to share with your fellow readers, please drop us a line to the email address below, and we'll share them on our letters page. Happy building!

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Intel Core i9-9900K Set to Break Records

Intel readies ninth-gen chips, but we have to wait for 10nm

INTEL HAS YET to officially announce its 9000-series chips (as we write), but motherboard manufacturers and others have been leaking details left, right, and center. MSI, Asus, and Gigabyte have all let slip their support for 9000-series chips, including the welcome news that you won't need a Z390 chipset, just a BIOS-updated eighth-generation one.

The 9000-series is branded as ninth-generation chips, but is actually little more than a set of slightly faster eighth-gen ones. Essentially, Intel is squeezing as much as it can out of its existing 14nm Coffee Lake architecture, now on its third generation, principally because it hasn't got much else ready yet.

Last month, details of the i3 and i5 versions were widely leaked. This month, it's the turn of the faster ones, though nothing is confirmed so far. We have the Core i7-9700K, effectively replacing the i7-8700K; rumor now has it that the i7-9700K will move to eight cores, but drop Hyper-Threading. It'll have a base clock of 3.6GHz, and a 4.9GHz Turbo. If true, this would put it roughly on par with a Ryzen 7 2700X, at a similar price point, which is surely no coincidence.

At the top of the tree is the Core i9-9900K—note the "i9" designation, now used on a mainstream desktop chip. There are benchmarks of this one about, taken from an engineering sample. It's an eight-core, 16-thread chip, backed by 16MB of cache. The base clock is 3.6GHz, and a Turbo mode of up to 5GHz (gasp). It's supposedly a 95W TDP part, so expect some serious cooling. Both top 9000-series will feature soldered heat spreaders to help with this.

The initial test results look good, and have lead to some overly aggressive things being written about how it "thrashes" a Ryzen 7 2700X. Sure, it'll be faster. This will be Intel's new halo desktop chip. And Intel does like its halo chips. It will also be horribly expensive—probably $450–500 a pop. AMD will remain the value choice across practically the whole market, but Intel can at least hold the crown as the fastest.

Intel is facing increasing competition from AMD, and it shows. Barclays Trading Hub downgraded its rating for Intel shares, its analyst lowering the price target by 7 percent. The technology lead Intel once had over AMD is eroding. It's not just at the desktop level either. The profitable server market, specifically the single-socket market, which has been a traditional Intel stronghold, and a profitable one, has seen huge inroads by AMD's EPYC chips. Intel will not be shipping its 10nm chips until next year, while AMD will start production of 7nm GPUs and CPUs toward the end of this year.

It's been years since Intel faced such rivalry across so many sectors, and one with such depth. AMD has had excellent processor designs before, which have embarrassed Intel, but it never lasted long. Intel could always throw capital at the shortfall, while AMD would struggle to follow up on its initial design. This time, AMD's Zen architecture is not only sound, but has a roadmap that moves into the server market, and into the years ahead.

But this is Intel; it has deep pockets, and it will respond. What is clear is that it won't be for months yet. Until then, it has to keep us amused with tricks and refreshes. The Core i9-9900K will capture headlines, and have fanboys in a lather. The official 9000-series launch will be soon now, and we'll see exactly what we are getting, and as every good showman knows, it pays to have something new at the final reveal (that's what we hope for, anyway). **–CL**

> AMD will remain the value choice, but Intel can at least hold the crown as the fastest.

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RISE OF THE BIG FOUR

Record gains and losses made as balance of tech giants shifts

FACEBOOK HAS MADE the record books again, by posting the largest ever one-day drop in market value in US history. It took a $119 billion tumble at the end of July, prompted by lower revenue growth and a slowing in the number of new accounts, the most sluggish ever. Zuckerburg took a personal loss of $17 billion. Twitter took a 20 percent hit, too, after it announced lower user numbers, caused largely by the deletion of fake and offensive accounts. Netflix suffered a similar fate on lower than expected subscriber growth.

Apple is heading the other way. It made the record books by becoming the first public company to be worth $1 trillion, helped by profitable iPhone sales and cloud services. Amazon is riding high, too; its Amazon Web Services now provide the bulk of its profit. Cloud services are also providing healthy amounts of cash for Microsoft and Google.

It looks as if the "Faang" group of high-fliers (Facebook, Apple, Amazon, Netflix, and Google) is making way for a smaller group of companies, "Maga" (Microsoft, Apple, Google, and Amazon). These are more focused on the infrastructure of the Internet, and Internet services, rather than ad revenue, subscriptions, or user accounts.

Facebook and friends are vulnerable to people's caprice. The fuss over offensive content, fake accounts, privacy, and other issues highlighted this. User-lead growth can lead to huge highs, but people can be fickle, and numbers can be hit by legislation, and even relatively small scandals.

Facebook et al will bounce back—they hold a wealth of valuable data for starters—but they are vulnerable. Predicting the end of rocket-like growth of innovative tech stock would be foolish, but there is something to be said for investing in the infrastructure of the Internet and tech. An active user account can disappear at any moment, but a server farm is a server farm forever. **–CL**

HUGE DATA GATHERING OPERATION UNCOVERED

11 MILLION BROWSER HISTORIES RECORDED

AN INVESTIGATION by AdGuard into Google Chrome browser extensions has uncovered a worrying set of spyware. There are nine suspects, all registered to a previously unknown company called Big Star Labs: Block Site, AdblockPrime, Mobile Health Club, Poper Blocker, CrxMouse, Speed Booster, Battery Saver, AppLock, and Clean Droid.

All are collecting your browser history, and passing it back to Big Star Labs, without asking for explicit consent. Not strictly illegal, but against Google policy. The extensions include a unique identifier with the data they collect, so it's easy to collate, and directly link your browser history to your real identity, potentially saleable, potentially troublesome.

AdGuard says it hasn't been able to track down who is getting the data collected. The recording of online activity is increasingly common; data on you has value. Many extensions collect browser history; it is supposed to be anonymous, but it is anything but. **–CL**

APPLE FIXES NON-PROBLEM

New keyboard is fixed—unofficially

APPLE'S MACBOOK PRO had a problem with its butterfly switch keyboard from the start. If dust finds its way underneath, it can operate oddly, or stop working. You can't remove the key and clean it as it voids your warranty and, more importantly, you'll probably break it.

Apple has finally added a silicon membrane around the keys to keep out dirt. In the promotional material for the new MacBook Pro, it claims the keyboard has been redesigned to be quieter. However, in the service manual, it says that the purpose is to prevent "debris from entering the butterfly mechanism."

Why the reticence? There are three class action legal cases in the works over faulty keyboards; these things tend to hit Apple in bunches, then coalesce. The cases cite design defects, fraudulent concealment, unfair warranties, and more. So, if Apple announces to the world that it has "fixed" the problem with the keyboard, it also announces that there was a problem in the first place, and opens itself up to potentially be saddled with a costly replacement scheme. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

COMPUTER IN DUST MOTE
Researchers at the University of Michigan have built a "computer" that's 0.3mm per side. The Michigan Micro Mote measures temperature.

VIRGIN GALACTIC IN "SPACE"
A test flight achieved 1,832mph and an altitude of 170,800 feet, reaching into the mesosphere, or near space.

WINDOWS SMART REBOOTS
Machine learning will be used in the next Win 10 update to control when your machine updates and reboots; it'll learn when you use it the least.

TRAGEDIES

HACKER STEALS $5M
A student hijacked 40 phones using a SIM swapping scam to steal cryptocurrencies and sell social media accounts.

GOOGLE BOWS TO CHINESE
Google is developing a search engine for China that can be censored by the state.

VIRUS STOPS PRODUCTION
TSMC had to halt production for more than a day after a virus attack on its machines; it makes silicon for Apple and Qualcomm.

Welcome Back to the C64

GAMING NOSTALGIA is big business. New "mini" versions of old-school Nintendo gear have been huge sellers, and now the Commodore C64 is to receive the same treatment. The C64 Mini is due this October, and is expected to sell for around $80. The dinky machine is roughly half the size of the original, and comes with 64 built-in games. There's a joystick, two USB ports, and a 720p HDMI output. The keyboard is just for show; you'll need to hook-up your own USB one if you actually want to type anything.

The games include classics such as *Boulder Dash, Summer and Winter Games, Armalyte, Speedball II,* and *Impossible Mission.* However, many favorites, like *Lemmings, Bard's Tale, Elite, Manic Mansion, Pirates!,* and the *Ultima* series, are missing.

The Nintendo gear was such a success not because of the hardware, but the inclusion of old games. The C64 Mini is missing much of what made the original so much fun. You can source and load games via USB, but it would have been better to have had them already loaded, even if it did add a few bucks. Meanwhile, you can still enjoy revisiting the '80s, in all their blocky glory; a new full-size version is due later this year, with more games, we hope. Can we have *Zak McKracken and the Alien Mindbenders,* please? **–CL**

World's best-selling home computer gets the mini treatment.

Criminals in Congress

Amazon has been working with law enforcement agencies on a controversial face recognition system, Rekognition. It aims to match up to 100 faces in an image against a library of millions, to spot, well, criminals, presumably.

The American Civil Liberties Union ran pictures of members of Congress through the system. Comically, Rekognition matched 28 members with criminal mugshots. The ACLU claimed the system had an accuracy of about 80 percent—way short of anything useful. The exact testing procedure is unclear, but apparently was put together for an Amazon fee of $12.33.

Face recognition will work, and is fine in a limited environment, such as unlocking a phone. However, there is still a lot of work to do to. The ethical dimension of scanning the general population is another matter. The tech is coming; we need to understand it, and be ready. **–CL**

MoviePass Burning Through Capital

For a subscription of under $10 a month to MoviePass, you can go to the movies every day (initially, anyway). In 2012, it was named in Business Insider's "Best of Everything." It also earned a place in the year's list of the 25 "Most Disruptive Apps." By this summer, it had three million subscribers.

Behind the scenes, all is not well. The company has restructured its prices, changed the number of films you can see per month, added peak pricing, and excluded some major titles. It recently rescinded many of these restrictions, but now you can only watch three movies a month before having to pay extra. All this has not helped profitability; it's burning through capital at an alarming rate. Last month, it needed an emergency loan to keep running. It seems it was too good a deal after all; enjoy it while it lasts. **–CL**

NO MAN'S SKY IS BACK

Have we finally got the game promised in 2016?

THE LATEST UPDATE for *No Man's Sky,* called *Next,* has managed to push the game up Steam's charts. As we write, it's the sixth most popular game being played. Quite a turnaround for a title that crashed and burned so badly in 2016.

No Man's Sky's claim to fame is its vast procedurally generated universe. You're free to explore, trade, craft, and fight as you journey to the center of the galaxy. There have been four major updates, but it's this latest one that's turned things around. *Next* was launched on July 24, at the same time as the Xbox One version, and compatibility with the Chinese WeGame distribution system. It overhauls the game engine and, more crucially, adds support for multiplayer.

No Man's Sky was originally released in August 2016, after considerable promotion. Talk of 18 quintillion planets to explore had gamers itching to enter its huge sandbox. On launch, it sold well, and peaked at 212,321 concurrent players. Then it all went wrong.

Promotional material had features that hadn't made the final cut. It looked pretty, but gameplay was repetitive, and it could be played through rather quickly if you didn't hang around and admire the scenery. People complained loudly. The number of players crashed to under 1,000. There was a huge gap between expectations and actuality. The game became something of an abject lesson in how not to handle marketing, with its bubble of hype, disillusionment, and backlash.

The developer, Hello Games, has stuck with it, and now we have something that looks more like the game we were hoping for, complete with a multiplayer mode, albeit a limited one. A true open MMG with a galaxy this size would be almost impossible technically, and anyway, even with all of Earth's population playing, the chances of meeting someone at random would be next to zero. It looks as if *No Man's Sky* is going to make it after all. **–CL**

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Jarred Walton

TECH TALK

Spectre Haunts SSDs; QLC & 3D NAND Aren't Afraid

ONE OF THE BIGGEST STORIES of 2018 so far has been the Meltdown and Spectre exploits, and the fallout keeps coming. Recently, while testing a new batch of NVMe SSDs, some oddities started popping up. In short, performance was far worse than expected.

The poor results weren't just with the new drives: All the fastest NVMe SSDs had lost performance. Sequential read/write speeds were still high, but random IO had dropped, and more critically, it took a significant hit for low queue depths.

That last point is important, because while SSD manufacturers love to show maximum random IO performance at queue depth (QD) of 32 or even 64, most real-world work happens at QD1, and over 99 percent of reads and writes happen below QD4. The lower performance first came up in early May, right after Microsoft rolled out the April 2018 update to Windows 10. Digging a bit more, it looks like a combination of Spectre firmware patches for Intel platforms and the latest Win 10 update are to blame.

Using a Z270 system without Spectre firmware, running Windows 10 Creators Update (version 1709), initial QD1 read/write results are 75.9/236.3MB/s. Updating the firmware to incorporate Intel's Spectre fixes dropped performance to 70.1/181.2MB/s. Applying the April 2018 update (version 1803) to Windows 10 resulted in a further drop to 59.9/177.6MB/s. That's a 21 percent drop in read speeds, and a 25 percent drop in write speeds. The kicker is that similar performance (using Samsung's 970 Evo 500GB as the guinea pig) showed up on Z270, Z370, and X299 Intel platforms with Spectre firmware patches and Win 10 April 2018. Switching

> With up to 1.33Tb per chip, we could see multi-terabyte SSDs with only two NAND packages.

Intel 4TB QLC SSD using four NAND packages; up to 20TB is planned.

to an AMD X470 platform delivered 72.8/206.2MB/s; still a bit slower, but better than any Intel system.

To be fair, most real-world workloads don't run purely random IO, but the reduced performance shows that earlier statements suggesting the impact to system performance would mostly be seen in data-center workloads aren't accurate; even home PCs can be affected. These results also show that we're not yet clear of the reach of Spectre and similar exploits, with new variants being announced on a regular basis. In other words, these aren't the sort of patches where disabling them to regain lost performance is a viable option. There is also some hope that affected software can be changed to work better within the post-Spectre ecosystem, and future updates to both firmware and Windows 10 may alleviate some of the pains.

It's not all doom and gloom, though. After over a year of climbing SSD prices, things are returning to 2016 levels, and sub-$100 500GB drives are now common. We're not likely to stop there either, as many manufacturers are pursuing QLC NAND. That increases the complexity of reading and writing data to NAND, with four bits per cell (compared to TLC's three bits, and MLC's two bits), but improvements in 3D NAND and controllers make the approach viable, especially for read-heavy workloads.

Intel, Micron, Samsung, and Toshiba are all talking about QLC NAND, and while the names vary, the idea is the same: 33 percent more data in the same space compared to TLC, or twice as much data as MLC. One of the driving forces of QLC NAND adoption in SSDs appears to be 3D NAND, and specifically the move to 96-layer designs. Toshiba's BiCS4 QLC will allow for up to 1.33Tb per chip (and multiple chips in a package), meaning we could see multi-terabyte SSDs with only two NAND packages.

More importantly, Samsung is talking about terabyte-class SSDs becoming mainstream by 2020. We're already seeing 1TB SSDs in the $200 range, which means in the next couple of years, we could see prices drop by half. The days of the spinning disk may finally be coming to an end, and 20TB and larger SSD capacities are in the works.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

DO NOT TRY THIS AT HOME

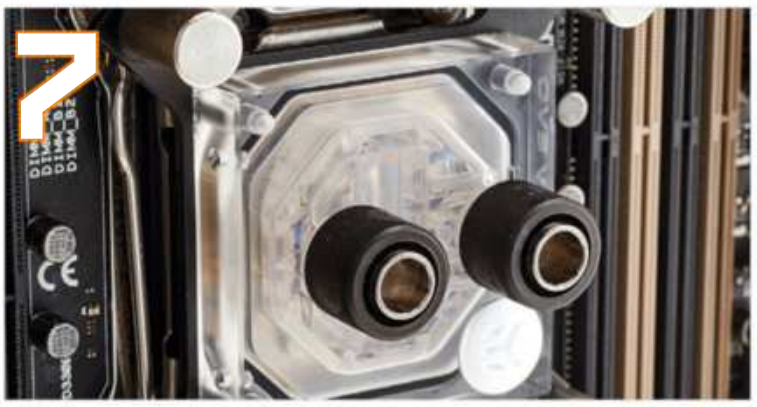
THE LIST

TOP 8 WAYS TO KILL A PC

8

DELID IT Which would you prefer: a small boost in cooling, or a boring CPU? Smash that lid off, Superman.

7



WATERCOOL IT Blasting it with a firehose, or worn, cracked, or poorly fixed liquid gaskets are deadly.

6

OVERJUICE IT Taking your PC abroad? Leave your PSU set to 115V and plug in to let the magic smoke out.

5

HEAT IT Every PC deserves to be toasty. That mat of pet hair, skin flakes, and who-knows-what should help.

4

"TEST" IT The USB Killer v3 from http://usbkill.com deliberately fires -200V DC over a victim PC's data lines. Ports tend to dislike this.

3

UNLEASH IT Go crazy with the BIOS. Overclocking? All of it. Temp throttles? No thanks. Safety is for wimps.

2

MAINTAIN IT Percussive maintenance is obvious, but try using a stainless-steel scourer on your mobo, too.

1

FRAGMENT IT Defragmenting? Pah. YouTube's Taofledermous got a .44 Mag to go through three drives.

Alex Campbell

OPEN SOURCE

Bad Packages: Getting More Than You Asked For

THERE'S THIS THING about Linux that any fan likes to parrot: "Linux is more secure than other operating systems." While this is largely true, it should never be misinterpreted as "Linux never gets any malware." Malware does exist for Linux, just not on the same scale as it does for Windows.

If there's one complaint I hear about Windows 10, it's that the OS forces updates on the user. Despite all the whining, this is generally a good thing, since users can't be trusted to update their systems regularly. Even with Windows' forced updates, there's a flaw: A Windows update can update drives and core components of the OS, but rarely includes updates to any other software, save that sold by Microsoft or distributed on the Windows Store.

A system like the Windows Store has been around for ages in Linux, in the form of package managers and software repositories. The problem is that repositories can't offer every piece of software. For some distros, such as Mint and Ubuntu, software review results in software being behind what the upstream creators have available. Rolling release distros, such as Arch and OpenSUSE Tumbleweed, throw caution to the wind, and release updated packages as soon as possible, leaving it to the users to know which packages will break their systems.

The Linux way is great until there's a piece of software that's not in the repos. Users have to decide who they are going to trust, but that choice can be overridden by a drive to install the software and move on. Users might be less concerned about the maintainer of the PPA or Arch User Repository (AUR) package if it means getting back to what they want to be doing. With popular and regularly maintained packages, this is rarely a problem—until said package is no longer regularly maintained.

In July, it was reported that a PDF reader package in the AUR called Acroread had been co-opted by a user who inserted malware into the PKGBUIL—a file that gives directions to the system to download and install the package. (The package has since been rolled back.) The offending package maintainer had inserted the malicious instructions after the package had been abandoned by its maintainer. A similar rash of bad images were reported in Docker Hub.

Gnome Software is generally a safe place to look for apps.

So, being safe might mean using older versions of software, and using newer or unsupported software may mean placing your trust in another party. Some solutions have appeared in the form of containerization. Flatpaks, Snaps, and AppImages offer distribution methods to developers who don't have the time or desire to port their software to all the major distros. However, some of these can introduce other problems. The Flatpak installation of Zotero can't install its plugin into the Flatpak version of LibreOffice, for example.

To protect yourself, first make sure the software is from who it says it is, and inspect things such as PKGBUILDs, Dockerfiles, or install instructions on the web. (Copy and paste, so you know what each command does.) When possible, prefer packages and containers created by the upstream source. If in doubt, use an installation method preferred by the developer. I prefer Flatpaks, AppImages, Snaps, official repositories, and the AUR, in that order. When using Docker, prefer images from official or well-known and documented sources. If in doubt, check the upstream Git repository for documentation, and ensure that more than one person is helping maintain the project.

Linux can be the most secure OS, it just requires a little vigilance.

Alex Campbell is a Linux geek who enjoys learning about computer security.

HEAD TO

BY **JEREMY LAIRD**

PC Monitor vs. HDTV vs. Projector

A big-screen PC is a blast. In days of yore, hooking up a PC to a TV via a low-res analog interface was fun, but it was also blurry, borky, and sub-optimal. Today, everything is crisp, clean, and digital. TVs offer high-res 4K panels that match or exceed most PC monitors for pixel count, and in the case of HDTVs with HDR support, color depth and contrast, too. Even projectors now support proper PC-size pixel grids. So what makes for the best big-screen experience?

ROUND 1

Price

In this age of dirt-cheap HDTVs, you might think there can be only one winner. After all, how do you argue with something like a cheapo 40-inch 4K TV on sale for something ridiculous like $300? In terms of absolute wallop for your wallet, you don't. However, the affordability of the latest HDTVs happily has a knock-on effect for the PC monitor market as a whole.

For instance, there are several monitors that are essentially 4K TVs repackaged and fitted out with electronics more suitable for PCs. Such screens are far cheaper than they otherwise would be, thanks to the huge volumes in which those big HDTV panels are cranked out. More generally, HDTV production on an epic scale pushes down the price of LCD panel tech, and has shifted expectations when it comes to the resolutions of cheaper screens. In short, 4K has become the norm thanks to HDTVs, not PC monitors.

As for projectors, they don't really get a look in when it comes to value. Big, bold, and cinematic they may well be, but when even the cheapest true 4K projector costs thousands of dollars, a beamer isn't even in the running when it comes to bang for buck.

Winner:
HDTV

ROUND 2

Pixel Pitch

This is where PC monitors used to have their big advantage over hooking up an old-school CRT TV via S-video or component. PC monitors typically had a huge resolution advantage, while also being physically smaller. Cue massive pixel advantage. That's no longer quite as true. 4K HDTVs now offer 3840x2160 pixel grids, and that's pretty much as good as it gets for computer monitors. Granted, some 5K and even 8K monitors do exist, but they're typically very pricey affairs.

However, particularly when it comes to productivity work, a good PC screen is about more than simply pixel count. Pixel pitch counts, too, and it counts against both projectors and HDTVs. The bigger the screen, the bigger the pixel, leading to less clarity and sharpness, rougher font rendering, and so on. Moreover, if you're not increasing the overall pixel count, you're not getting any additional on-screen elbow room to work with. Of course, you could sit further away from your HDTV or projector screen, and thus solve the pixel pitch problem, but if the apparent size is then the same as a smaller monitor situated closer, what is actually the point in having the larger screen?

Winner:
PC monitor

ROUND 3

Connectivity

Another area where TVs and projectors used to fall short, the connectivity gap has shrunk of late thanks to digitization. The HDMI 2.0 interface used by HDTVs and projectors, for example, is broadly comparable with DisplayPort 1.2 when it comes to bandwidth. Both support full 4K resolutions at 60Hz refresh.

But that's not the full story. The PC-centric DisplayPort interface is far more flexible and offers not just multimedia transmission, but also compatibility with USB Type C's alt modes, plus features such as daisy-chaining. That means you can use a single cable to connect a PC to a monitor, and have everything from image and sounds to USB connectivity and even charging catered for. The HDMI ports in HDTVs and projectors aren't nearly as powerful and versatile.

HDMI's support for more advanced features is also patchy, and adoption of updates to the standard tends to slow as the industry favors compatibility over capability—support for adaptive refresh via HDMI remains rare, for example. 4K at 120Hz also remains the preserve of monitors with the latest DisplayPort 1.4 interface, for now. The upcoming HDMI 2.1 standard ups the bandwidth ante, but isn't offered by any PC graphics card yet.

Winner:
PC monitor

HEAD

Monitor: If you want a superwide screen, it has to be a PC monitor.
HDTV: Unbeatable big-screen bang for your hard-earned buck comes with an HDTV.
Projector: Beamers make for fulsome if inflexible big-screen fun.

ROUND 4

Image Quality

Not long ago, image quality would have been a sure win for PC monitors. Lately, the comparison has become more complicated, thanks to the emergence of new HDR, or High Dynamic Range, standards in the HDTV market.

HDR means greater differences between the brightest and darkest areas of the screen, and thus better contrast. But HDR standards also incorporate extended color spaces, and thus a wider range of colors. Meanwhile, the PC monitor market has been slow to adopt HDR. The consequence is that many HDTVs now have the edge on mainstream monitors when it comes to color depth and contrast. The latest HDTVs also often offer reasonably low input lag when receiving a PC signal.

The qualifier is that those on-paper capabilities don't always translate into better image quality in all areas. HDTVs tend to use aggressive image processing, which can sacrifice accuracy in favor of superficial pizzazz. As for projectors, it's a tough comparison to make. Projectors, too, have embraced HDR technology, but the need for a dark viewing environment and the inherent difference between transmissive and reflective technologies put projectors in a category of their own.

Winner:
PC monitor

ROUND 5

Features

The features offered by monitors, TVs, and projectors reflect their remits. So much depends on what you want to do. Gamers will find that features such as adaptive sync support and low-input-latency modes are exclusive to PC monitors designed for gaming. Likewise, productivity features, such as USB hubs and accurate factory color calibration, are the preserve of PC monitors too.

PC monitors also tend to be better engineered for mounting and being situated ergonomically on a desktop, be that courtesy of an adjustable stand, VESA mount compatibility, or the range of LCD panel aspect ratios on offer. TVs hit back with multimedia features such as built-in tuners, smart TV platforms, and impressive app support. Indeed, an HDTV is the only one that can function on its own and do things like play back video files from a USB stick. In effect, HDTVs have computers built into them.

Projectors tend to have a much narrower remit, and with that comes fewer features. Some support wireless connectivity in order to improve mounting options and reduce the need for running cables, but that aside, specific features to support PC gaming or productivity are non-existent.

Winner:
PC monitor

And the Winner Is...

So, PC monitors come out on top for use with PCs. Not exactly a newsflash, you cry? Maybe not. But despite the scale of the victory in terms of category wins, this contest is much closer than it looks. If you're on a tight budget and you want a big, beautiful 4K screen, for instance, an HDTV is not only a great solution, it may be your only option. The latest HDTVs offer far better image quality than the TV sets of old, too.

However, the strength of the PC monitor is that its features and performance are optimized for PC usage. It's better at connecting with PCs, more suited to displaying a PC's output, and more physically compatible with a PC's usual working environment. Whether it's high refresh rates for games, color accuracy for producing content, or something as simple as font rendering for reading, PC monitors remain your best bet when using a PC. The exception involves home theater and multimedia PCs, where the huge, cinematic scope of an HDTV and particularly a projector can create images and a viewing experience on a whole different scale.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Droves of Drives
> Monitor Madness
> Power Options

Checkerboard Screen

Hey, Doc. I've started getting a checkerboard pattern on my laptop's display, either across the whole screen or limited to certain dialog boxes. I have a 15.3-inch Sager notebook with a Core i7-6820HK processor at 2.70GHz, an Nvidia GeForce GTX 980M graphics module, a 64-bit operating system, and 16GB of system memory. Is my graphics card in its death throes? **–John Digilio**

THE DOCTOR RESPONDS:
The issue you're describing can be caused by software or hardware. Some of the potential problems are easy to troubleshoot and solve; others may be harder to diagnose.

A simple first step is to verify that you're running the latest drivers for your graphics adapters. Uninstall the existing packages for Intel's HD Graphics 530 engine and Nvidia's GeForce GTX 980M using Windows' Control Panel. The Doc likes to follow up with a utility called Display Driver Uninstaller, which ensures old files and Registry entries are cleaned up, too. Download the most up-to-date versions for both, and see if they resolve your display corruption.

If they don't, try digging deeper. Is your integrated graphics enabled when the checkerboard pattern appears? Try switching to the discrete GPU exclusively. Overclocking and overheating are two more potential causes. However, in a properly functioning PC, the Windows desktop doesn't generate much of a load. Software such as AIDA64 or HWiNFO64 can tell you when thermal readings get too high. If temperatures spike, verify that Sager's cooling subsystem is operating correctly.

Hopefully, your symptom doesn't indicate a more serious malfunction. Underclocking your system RAM and the graphics board's GDDR5 memory may help determine whether a module is failing.

Attach up to 24 SATA hard drives to Microsemi Adaptec's HBA 1100-24i without compromising performance.

Many Hard Drives

Hi, I'm upgrading my motherboard to an Asus ROG Strix X299-E Gaming with a Core i9-7900X. I also plan to add 20 to 25 3.5-inch mechanical hard drives. I bought a custom Origin PC desktop a while ago, so I'm using its Genesis chassis, which has a bay that can store a dozen 3.5-inch hard drives.

What I can't figure out is what PCIe-attached SATA cards I can get to connect the hard drives, each with its own dedicated lane. I need at least 12 extra ports, and the best I can find are four-port PCIe SATA x2 adapters. Aren't those going to reduce the throughput from each disk to less than its maximum? Is there something else I should be looking at that will allow for peak throughput on each drive? I don't want to create any chance of contention, because I'll be using software RAID once the disks are installed, and who knows what problems I'll encounter if there are limitations because of the PCIe SATA card? **–Mike Barylski**

THE DOCTOR RESPONDS:
Your motherboard features three PCIe x16 slots, one of which accommodates 16-lane devices, and two of which are wired for x8 links. Assuming you plug a graphics card into the top slot, each of the x8 connections offers nearly 8GB/s of throughput in both directions. That's quite a bit of bandwidth—so far, so good.

Let's say you can get a max sequential transfer rate of 250MB/s from one hard drive. With 24 disks, you need 6GB/s to avoid bottlenecking, which is less than what's available from an eight-lane PCIe 3.0 slot. Again, the math is promising.

A host bus adapter such as Broadcom's SAS 9305-24I or Microsemi Adaptec's HBA 1100-24i drops right into a x8 slot and supports 24 direct-connected SAS or SATA drives through a sextet of Mini-SAS interfaces. Each costs more than $500, but if you're serious about storage, options abound beyond four-port SATA cards.

4K/144Hz Monitors

Hey Doc, In the June issue, you suggested that Erik

↘ submit your questions to: doctor@maximumpc.com

Aukerman wait for next-gen graphics cards and 4K/144Hz monitors. The issue is, those panels don't display in full 4K at 144Hz with HDR; DisplayPort lacks sufficient bandwidth for those specs. Right now, it would likely be better to dig into where that bandwidth becomes an issue, and purchase a display with the corresponding refresh rate, be it 75 or 100Hz. As he said, super-high frame rates aren't necessarily important.

–Kurt Colbourne

PA32UC offers 4K, HDR, and accurate color reproduction for $2,000.

THE DOCTOR RESPONDS: Thank you for bringing this up. The Asus ROG Swift PG27UQ and Acer Predator X27 both claim support for resolutions up to 3840x2160, peak brightness of 1,000cd/m² with high dynamic range enabled, and refresh rates as high as 144Hz over a DisplayPort 1.4 interface. However, DP1.4 only provides enough bandwidth for 3840x2160 at 120Hz at 8 bits per channel color depth (that is to say, without HDR). So, images are encoded with less color information through a process called chroma subsampling, reducing the bandwidth they use. This compromise in picture quality is what makes it possible to run at 4K/144Hz.

If you look at both monitors' specifications, you'll see that Acer and Asus claim native support for 3840x2160 at 120Hz over DisplayPort. They refer to 144Hz as an overclocked setting. But even at 120Hz, you're limited to 8 bits per channel color depth if you want true YCbCr 4:4:4, or full resolution on all components. In short, they impose some trade-offs to achieve 3840x2160 at 144Hz. Running them at 4K/120Hz and 8 bits per channel may be the best compromise for now. It's just a shame that such a word is necessary in the context of a $2,000 monitor.

More 4K Madness

Hi Doctor, I have been happily using a Dell U3011 for quite a few years. Once video card and memory prices return to normal, I will be upgrading to a 4K-capable desktop PC. In the meantime, I would like to upgrade my monitor to a 32-inch 4K model as well. Neither curved nor wide panels interest me. Are there any displays superior in every way to what I have? What about DisplayHDR? I know there are 400 and 600 models available, but is a 1000 model on the horizon? I don't mind spending a good chunk of change, since I will be looking at it every day.

–Rob Swan

THE DOCTOR RESPONDS: Your U3011 was a premium display back in 2010, sporting a 30-inch IPS panel with 10-bit color depth, a native 2560x1600 resolution, and a brightness of 370cd/m². By all accounts, it was a winner, at under $1,500.

There are plenty of monitors that would be an upgrade, but if you filter them down to 32-inch 4K-capable models, Asus's PA32UC looks like one of the best (as of this writing, it's not widely available, but previews praise its performance and functionality). VESA does not list the PA32UC as DisplayHDR-certified yet, but it does bear an Ultra HD Premium badge, indicating a 3840x2160 resolution, support for 10-bit color depth, and HDR10 compliance. Asus specifies a maximum brightness of 1,000cd/m² and 95 percent DCI-P3 color space coverage. Expect to spend around $2,000 for the privilege of owning one, once supply improves.

If you're willing to compromise on screen size, Acer's Predator X27 and Asus's ROG Swift PG27UQ are both 27-inch monitors that sport 4K resolutions, along with $2,000 price tags. Although gamer-oriented, the pair represents two of the three products currently boasting DisplayHDR 1000 certifications. The third is Philips's 43-inch Momentum—a much different beast, with an MVA panel overclocked to facilitate 80Hz refresh rates.

PSU Upgrades

Doc, In the latest issue, you replied to a question from Leon Garfield concerning the installation of a new power supply in his Dell Precision Tower 3620, but your answer didn't really solve his issue.

I, too, have a Dell Precision Tower 3620 that I wanted to upgrade with a PSU larger than anything Dell offered. After searching around, I found several solutions from companies such as COMeap, Eyeboot, and modDIY that were affordable and easy to install. I purchased one, along with a much more powerful 80 PLUS Gold-rated modular power supply. Now I have plenty of juice to drive any component I want to upgrade.

Tier-one manufacturers may continue to produce proprietary parts for their machines to garner a captive audience, but where there's a will, there's a way around them.

–David A. Glasser

THE DOCTOR RESPONDS: Thank you for sharing your experiences, David. Based on the links you sent, it appears there are several 24-to-8-pin adapters able to standardize Dell's proprietary connector and extend compatibility to familiar ATX PSUs.

As mentioned in the Doc's response to Leon, stories abound of DIY efforts to splice cables together. Some work, others don't. Lacking evidence of a definitive fix, the Doc was not comfortable suggesting an adapter with unproven compatibility, not to mention potential safety implications. It's good to know that there are viable ways to make a 24-pin ATX connector work in Dell's Precision Tower 3620, though.

Please, Don't Sleep!

Dear Doctor, My PC's power plan changes on its own, defaulting to sleep mode after 15 minutes every time I boot up. The power settings worked fine under Windows 7, but Windows 10 doesn't save my preferences, forcing me to select "Never" in the "Power & sleep" menu every morning. I have tried creating custom plans, but they don't work. I also tried modifying settings in the Registry to no avail. Do you have any ideas? This was a fresh installation of the OS and not an upgrade from Win 7, so there wasn't any baggage carried over.

–Arvin Gilman

THE DOCTOR RESPONDS: It's probable that some software on your machine is changing the power settings. Intel's Ready Mode Technology is one offender, though it tries to serve a useful purpose by allowing the receipt of email, messages, social media posts, and so on through an alternative low-power mode. You can disable it from within Windows or in your motherboard's BIOS. Various antivirus suites reportedly contain options that alter Windows' power plans. And motherboard utilities, such as Asus's AI Suite, are also guilty of manipulating OS options on startup. If a quick check fails to turn up a solution, parse through Windows' Event Viewer for more evidence.

BACK TO THE BASICS BUILD GUIDE

An in-depth step-by-step budget build guide

BY ZAK STOREY

FOR THE EXPERIENCED, building a PC is an easy, often therapeutic experience. Each part fits into its designated slot, each cable is carefully woven around the frame, and each power-on is successful. However, for a vast swath of folk, it's nothing of the sort. PC building can be a daunting task, especially if it's your first time. After all, you're messing around with delicate parts that can cost upward of half a month's paycheck. One little slip, one jolt of static, one cable in the wrong place, and boom—you're out of pocket and out of luck.

So, why bother? You can pick up a pre-built PC for a similar amount of cash as building your own—and let someone else worry about everything. It's convenient, easy, and saves a whole ton of time. Combine all that with numerous tech sources and journalistic outlets (ourselves included) focusing on the very extreme end of computing, and finding the info you need to take you through the process of building a system right from the start is challenging.

However, the fact is that, more than anything, building your own system is actually a relatively easy and satisfying experience. It's about taking the exact hardware you want, and combining it all into something that suits you perfectly. By building your own rig, you know exactly what goes in it, where potential problems can arise, and what you can do to improve it. On top of that, it's yours. You built that, nobody else, not another company—you.

This time around, we decided to pull out a bit of a double whammy. Firstly, we're talking a $500 hardware budget, and an attempt to build a fairly respectable 1080p gaming machine, with all the gizmos you need, including 620GB of storage, an SSD, 8GB of DDR4, and a fairly meaty processor. Or, at least, enough to get by just fine with the latest titles. We're combining that with a super-granular, in-depth guide to take you from the very beginning to the very end of your own budget build.

INGREDIENTS

PART		PRICE
Case	**Cooler Master MasterBox Lite 3.1**	**$35**
Motherboard	**Gigabyte B360M D3H**	**$76**
CPU	**Intel Pentium Gold G5600**	**$86**
Memory	**8GB** (2x 4GB) **Crucial Ballistix Sport LT @ 2,400MT/s**	**$85**
GPU	**Gigabyte GeForce GTX 1050 2GB OC**	**$135**
PSU	**EVGA BT450 80+ Bronze**	**$38**
OS Drive	**120GB Kingston A400 2.5-inch SSD**	**$27**
Data Drive	**500GB Western Digital AV-GP 3.5-inch HDD**	**$19**
Cooling	**Stock**	**$0**
Operating System	**Windows 10 64-bit**	**$100**
Total		**$601**

PRICES WERE CORRECT AT TIME OF PRINTING: UPDATED PRICES AVAILABLE AT HTTPS://PCPARTPICKER.COM/LIST/3YQFFT

CPU

INTEL PENTIUM GOLD G5600 $86

Where would we be without the core wars between AMD and Intel? Since Intel has had to up its game and push more cores into its lineup, we're finally seeing some of the budget-oriented processors reach higher heights than we've seen in the past. The Core i3s are now akin to Kaby Lake i5s, and the Core i5s hold nearly the same multi-processing grunt as the old i7s. So, where does that put the Pentiums?

Well, this little beauty, coming in at $86, packs two full-fat cores, plus Hyper-Threading, to give us a total of four threads, all clocking in at a base frequency of 3.9GHz. That's not exactly a small figure there. Ultimately, all of those stats come together to give us a fairly fast Coffee Lake processor that's more than capable of driving the latest games with ease. It also comes with a cooler as standard, so win-win.

MOTHERBOARD

GIGABYTE B360M D3H MICROATX $76

With a good processor, you need a good mobo. We've sprung a little extra cash into this purchase, but in the long run, it's very much worth it. Gigabyte's B360M D3H is a microATX fun house of future connectivity. You've got multiple SATA ports, support for onboard USB 3.0 and 2.0, four PWM fan headers, support for all of the Coffee Lake series of processors (from our lowly Pentium all the way up to the Intel Core i7-8086K), and, more importantly for us, support for an M.2 PCIe SSD, which will be a massive boon if you do fancy chunking out for some beefier storage later down the line.

Unlike most systems out there, ours does have a fairly accessible and easy upgrade path, for those looking to get more out of their rig later down the line. It would be easy to throw in a Core i5, a beefier GPU, and a more advanced storage solution without breaking the bank. And on top of that, your mobo won't look out of place, either.

8GB (2X 4GB) CRUCIAL BALLISTIX SPORT LT @ 2,400MT/S $85

We've seen in the past that Intel-based systems don't really benefit much from advanced memory frequency speeds, outside of more intensive workloads, particularly video editing. And with the recent fall in memory prices, picking up an 8GB kit of dual-channel memory isn't quite as daunting as it once was.

8GB is plenty for all your gaming needs, especially at 1080p. It's likely that within the next four years, you may need to double that capacity, but only for the highest of high-end titles. Fortunately, the Gigabyte B360 motherboard supports four sticks of DDR4, so it would simply be a case of buying a second set of the Crucial Ballistix Sport LT featured above.

GIGABYTE GEFORCE GTX 1050 2GB OC $135

Nvidia's GeForce GTX 1050 2GB isn't going to wow your friends, but there's no arguing with how impressive it is regarding value for money. We've come a long way graphically in the last few years, with Nvidia's tenth-gen series of cards revolutionizing what you can expect across the range. To give some clarity to that, in our testing, the GTX 980 performs almost identically to a GTX 1060. The 1050 is a somewhat slower card than its bigger brother, but it still packs just enough punch to tackle most 1080p titles.

Basically, you need to be smart with your settings. You can't just throw everything to Ultra and leave it there if you want an acceptable frame rate. Most mainstream esports titles, *Overwatch*, MMOs, MOBAs, and the like will play well into the 100fps mark, but for any other graphically intensive title, you should drop the quality of the textures and lower antialiasing where you can to reduce the overall load on the GPU.

OS DRIVE

120GB KINGSTON A400 2.5-INCH SSD

$27

What would any modern system be without a solid, quick, and dependable hard drive behind its OS? Nothing, that's what. Sure, those old spinning platters may be far cheaper than their flash-based rivals, but nothing compares to having the instantaneous response of an SSD. It's one of the biggest leaps you can make as a PC enthusiast, swapping from a hard drive to an SSD, and we certainly wouldn't build a system nowadays without one. Whether it's 2.5-inch or M.2, there's an SSD for everyone, at any budget.

Because we're on a tight budget, we've gone for a 120GB model for our build. It's not the flashiest of drives, but it does pack impressive 500MB/s read and 450MB/s write speeds into its incredibly affordable frame.

DATA DRIVE

500GB WESTERN DIGITAL AV-GP 3.5-INCH HDD

$19

It's scary just how little you can pick one of these beasts up for nowadays. OK, 500GB isn't exactly an average-sized hard drive—ideally, you want something around double that size—but if you're on a budget, and don't mind being a little more scrupulous with your games and content, in this age of digital streaming at least, running with a 500GB HDD for your backup drive isn't exactly too much of a stretch.

Western Digital is one of the better hard drive brands out there. And although the AV-GP isn't one of its mainstream drive ranges, we've no doubt this $19 box of joy will serve you well. There is one caveat here: It does only support SATA 3.0 Gb/s, but that's still the equivalent of sequential read and writes nearing 375MB/s, and you won't find any spinning platters capable of driving those kinda numbers sub-$300.

PSU

450W EVGA BT450 80+ BRONZE ATX $38

We've stressed plenty of times in the past just how important buying a decent PSU is, and we'll stress it again: Regardless of price, always go with a named brand, because if things go boom, you want a company you can talk to, not some Amazon non-branded reseller. EVGA's BT450 is by far our favorite budget power supply. It packs plenty of juice for any modern-day system (twice as much as what is needed here under load), and also comes with an impressive three-year warranty. Of course, it's not the most efficient of power supplies, it's non-modular, and that warranty isn't as good as the 10-year titans EVGA also sells, but for the price, it's arguably one of the best choices you can make.

CASE

COOLER MASTER MASTERBOX LITE 3.1 MICROATX $35

Where would we be without a case? To be fair, if you were on a ridiculously tight budget, you could forsake the case and run the rig off the motherboard box (something we do for testing), but long-term, you'll want to get yourself something solid.

Cooler Master's MasterBox has been a solid favorite of ours for a while, and this microATX offering is no different. Although stripped down in comparison to some of the other MasterBoxes, the 3.1 still keeps some of the basic design elements, alongside a few nifty cost-cutting measures. Take the windowed side panel—it may look like tempered glass, but it's actually acrylic. There's not a huge amount of room for cable management, but the size of the rear side panel has been increased to compensate for your cable bulge. It still features a full-fledged front I/O, and, rather incredibly, white and black accents if you want to change out the red ones on the front panel.

The Budget-Busting 1080p Build

With just $500, is it possible to build a PC capable of gaming on today's 1080p planet? Let's find out...

BACK TO BASICS—how on earth did we come up with this one? Well, as graphics card prices have fallen, and the cost of memory is more reasonable than it has been of late, we thought it was time to see what you could do with an absolutely minimal budget. You'll notice we keep referring to a "hardware budget" in particular—that's because the operating system cost is one of the biggest variables.

In reality, this system is designed with Windows 10 in mind. You could game on Linux for free (or by paying a donation of your choosing), and we've covered that before—unfortunately, though, for now, Microsoft very much holds the keys to the kingdom. If you have a license already, it makes this build ridiculously affordable. Those not so lucky have two options: Either you can chunk out for a full license, bound to an email address, which will set you back around $100 or so; or you can see whether you can buy yourself an OEM one-time Windows 10 code online. These are typically available from less reputable sellers, and usually, if you can purchase a legitimate key, you'll find that it's a one-hit wonder. Pop that motherboard out, and whammo—you'll need a new key. We always recommend you pick up a legitimate Windows license from Microsoft, and anchor it to an email account. If you do, activating any new machine is a piece of pie. Simply log in with your Microsoft account, and you're good to go.

PRICE VERSUS PERFORMANCE

SO, WHERE DO YOU BEGIN with a build like this? Well, for us it all started with the processor. Knowing Coffee Lake to be the beast it is— and in a lot of ways, we have AMD to thank for this—means that we know those single cores can hammer out some seriously strong IPC. What that translates to is plentiful frame rates in game, and a smooth desktop outside of it. Thanks to the Coffee Lake core count bump, the Pentiums of today easily match the Core i3s of 2016 and earlier. In the process, they've become an ideal part for some low-end gaming.

Now, you could technically do something similar with an AMD build, but you'd be laying down a lot more cash in the process. Yep, we never thought we'd say this, but Intel's budget offerings are actually pretty incredible right now, and AMD currently can't match them on price.

Next on the list was the notion that prior to working for this mag, this journo was only using a GTX 660 2GB to game on back in 2015. All in all, it was a pretty comfortable experience, especially at 1080p. Games have come a fair way since then, but the reality is that game developers always cater to the largest portion of the community, meaning they need their title to look awesome on the high-end settings, but be accessible at the mid-range, too. The GTX 1050 2GB is the perfect fit, then. It's the successor to the GTX 950, which, in turn, supplanted the GTX 760 and the GTX 670. So it must, by default, be a capable gaming GPU.

Combine that with 8GB of DDR4 and a decent-sized SSD for your OS install, and you're suddenly looking at a very appealing platform for anyone who's looking at getting into PC gaming or building their kid a system to go back to school with, or simply someone who wants a good all-around machine.

INGREDIENTS

PART		PRICE
Case	**Cooler Master MasterBox Lite 3.1**	**$35**
Motherboard	**Gigabyte B360M D3H**	**$76**
CPU	**Intel Pentium Gold G5600**	**$86**
Memory	**8GB** (2x 4GB) **Crucial Ballistix Sport LT @ 2,400MT/s**	**$85**
GPU	**Gigabyte GeForce GTX 1050 2GB OC**	**$135**
PSU	**EVGA BT450 80+ Bronze**	**$38**
OS Drive	**120GB Kingston A400 2.5-inch SSD**	**$27**
Data Drive	**500GB Western Digital AV-GP 3.5-inch HDD**	**$19**
Cooling	**Stock**	**$0**
Operating System	**Windows 10 64-bit**	**$100**
Total		**$601**

PRICES WERE CORRECT AT TIME OF PRINTING; UPDATED PRICES AVAILABLE AT HTTPS://PCPARTPICKER.COM/LIST/3YQFFT

1 PRE-BUILD PREP

SO, THE HARDWARE'S TURNED UP, you've got a solid work area to build your rig in, and you're good to go. What's first? Well, after taking your woolly socks off and touching something metal to get that zappy goodness out of your fingertips, you're going to want to unbox your chassis. This is where you'll encounter a few issues. Firstly, with polystyrene and a plastic bag sliding out of a cardboard box it means that every case will almost always zap you with static electricity. So, de-charge yourself again immediately after you remove the case, polystyrene, and plastic bag from the box. Then place both the polystyrene packaging and bag back in the box for later.

2 CHASSIS STRIPDOWN

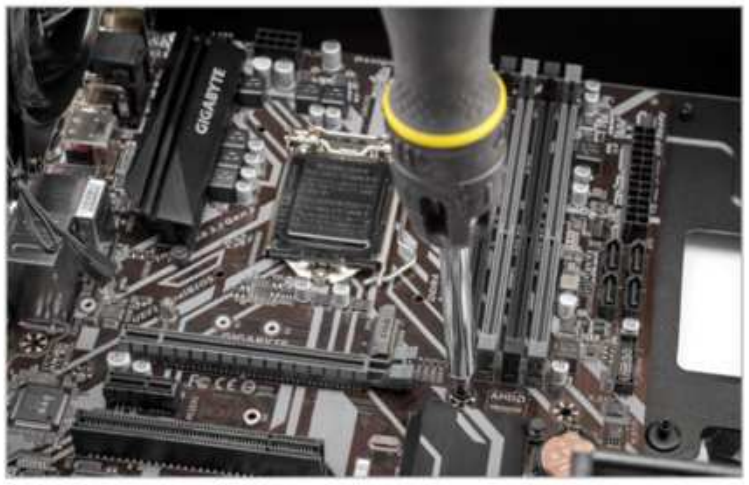
NEXT YOU'LL WANT TO EMPTY OUT the chassis as best you can. There's almost always some form of accessory bag included, with the relevant screws, cable ties, and other helpful things (in this case, a box with the black and white accents). Remove as many panels as you can, either by removing the thumbscrews, or by popping the plastic pegs out. Then place the panels back into the cardboard box for later. It's also worth getting a bowl of some description, in which to place the screws you'll be using, because it stops them from rolling around all over the place. Some of the thumbscrews can be overtightened from the factory, so it might be helpful to use a screwdriver to give you a little extra leverage on the tricky ones. Also, leave the front I/O cables tucked somewhere inside the case for later.

3 MOTHERBOARD I/O

THE NUMBER OF TIMES we've forgotten this little plate. Now you've got everything out the way, you can install the backbone of your system: the motherboard. First, open the box and find the rear I/O plate, located below the board with the accessories. It's a rectangle that goes in the back of the case to protect your I/O from damage. Look at your motherboard, see which side the holes need to be for each portion of I/O (audio is almost always closest to the GPU slots), then push the I/O bracket into place, from the inside of the chassis. It should click into place quite easily. Some of the more padded brackets can take a bit of extra force to get to sit correctly, and some premium mobos have I/O shields pre-attached, so you don't have to worry about those.

4 STAND-OFFS & SCREWS

DEPENDING ON YOUR CHASSIS, you might need to install the stand-offs yourself. These are tiny screws with a thread on the top that give your motherboard a raised platform to stand on. In our case, Cooler Master includes these inside the screw bag, with a neat Phillips head stand-off screw installer. Look at the chassis, and note the "M" on the pre-drilled threads in the case. This is where you need to install the stand-offs for your microATX motherboard. Check where the stand-offs are going against the screw holes on your motherboard. You may find some aren't on the motherboard, or the motherboard doesn't cover all the stand-offs—this is fine. Once you've got the stand-offs in, place the motherboard on top of them, wedge it up against the rear I/O plate, and screw it into place.



5 PROCESSOR INSTALLATION

NOW YOUR MOTHERBOARD IS SECURELY IN PLACE, it's time to install the big bad. And by that, we mean the processor. It's a scary business installing Intel processors, not least because if you bend one of those pins in the socket, it'll mean a quick RMA, and a halt on your build. For an Intel system, you're going to want to note the location of the triangle etched in the bottom-left corner of the silver CPU bracket. Push down and lift up the retention arm you can see us holding here. Then, noting the golden triangle on the corner of your CPU, gently place it into the socket. No wiggling, no forcing, just so the triangles are in alignment, and everything fits comfortably. You can leave the black plastic cover in place. Carefully secure the bracket back down under the screw, then push the retention arm back down and under to secure the CPU. The black plastic cover will pop off. If it doesn't, gently pull it.

6 THERMAL COOLING

PROCESSORS GET HOT, which means you need to cool them. We're using the stock fan Intel provides with its non-unlocked processors. It's more than enough to keep our build happy. Usually, we'd apply a small dot (half a pea size) of thermal paste in the middle of the processor before attaching a cooler of some description. However, in this build, the stock Intel cooler has thermal paste pre-applied to the bottom. Simply remove the plastic cover on the heatsink, line up the four pegs on each corner of the fan with the holes in the motherboard surrounding the CPU socket, and push them into place. Once there, rotate the pegs counterclockwise to lock it in place. Then run the CPU fan cable to a PWM fan header on the motherboard. These look like four pins, and are usually labeled. We recommend you install this into the CPU one. There's a notch on the cable to stop you plugging it in the wrong way, and you may need to remove the cable from the clips holding it on to the CPU fan to reach around the other way, as we have here.

7 MEMORY MATTERS

NOW YOU'VE GOT YOUR CPU FAN installed and plugged in, it's time to install the memory. You should have bought a dual-channel kit for your build. To install this, notice the notch on the bottom of each stick, where the connectors are. You need to line these up with the notches in the memory slots. Lift up the latches on both sides of each memory slot, then lining up the memory stick, carefully slot it into place, until both latches on either side click down securely. Additionally, unless you're installing four sticks, make sure you use the color co-ordinated memory slots, to enable dual-channel memory speeds. Under no circumstances should you be using a single slot of memory for your build, because this limits overall memory bandwidth by half, regardless of how much memory it gives you.

8 HARD DRIVES FOR DAYS

IN OUR BUILD, we have both a 2.5-inch SSD and a 3.5-inch HDD. The SSD is for our operating system, because it has limited storage, but is incredibly fast, and the 500GB HDD is for everything else. To install the 3.5-inch hard drive, slide it into the caddy, as pictured here, with the ports facing out toward the back of the case. Then, simply use one of the included thumbscrews to secure it in place. The SSD slots into the top, and is secured by two small screws at the front. We decided to angle the ports, so they were facing the motherboard, to make it a little easier to run the cables later. You can also install the SATA data transfer cables now. You'll find these in your motherboard box; they have L-shaped connectors. Connect one to each hard drive, then run it through the back of the case, and into one of the L-shaped ports on the motherboard.

9 POWER SUPPLY INSTALLATION

WHEN IT COMES TO INSTALLING the power supply, you have two choices: fan down, or fan up. In a liquid-cooled build or one with an AIO, we recommend you install it with the fan facing down. If any water leaks from the cooling block, there's minimal chance that gravity will drag it into the fan and fry the system. With the fan up, it draws warm air down and out of the chassis. It also affects how much play you have in the cables when you're installing them. Once the PSU is in place, simply use thumbscrews to secure three or four of the threads through the back of the chassis, then run the cables out through the back of the case, next to the motherboard.

10 FRONT PANEL FUN

SO, YOU'VE GOT THE PSU INSTALLED, and all the cables out of the back, so now it's time to plug in all the front panel connectors. Usually on the bottom-right of the motherboard, you'll find a selection of pin-outs to which you can attach the connectors. Your motherboard manual will tell you which connector needs to go where, but usually on the mid-range options and above, those details are actually written on the motherboard itself as well. With the MasterBox, the front panel connectors come bunched up on a group of wires, all attached together—you can pull these apart and separate them slightly to give you some leverage to plug them into the correct position. It's also a good time to plug the audio pass-through (located bottom-left), the USB 2.0 header (check the pin slots on each plug, so you don't get confused with the audio pass-through), and the USB 3.0 header into the motherboard.

11 ATX POWER INSTALLATION

NOW THE PSU IS IN, the front panel cables are all connected, and your USBs are firing, it's time to add some power to your system's main hardware. First up on the list is the 24-pin ATX power. You'll recognize this cable simply by its sheer size. Most power supplies come with a 24-pin that splits up into two segments: a 20-pin and a 4-pin. This is to support older motherboards that don't require the full 24-pin power. However, our system very much does. Simply clip the additional 4-pin power into place on to the side of the 20-pin cable, note the latch on the cable, line it up with the notch on the motherboard, and push it into place. Job done—first cable all sorted.

12 CPU POWER INSTALLATION

YOUR MOBO'S GOT JUICE, so let's sort out the CPU. Your EPS power cable looks like a PCIe power cable, although it usually has EPS or CPU written on the plug. Its pins are also different shapes, so there's no way you can plug a PCIe power connector into a CPU connector. On a bigger chassis with better cable management, you'd run it up the back of the motherboard and into the eight-pin socket. In our case, there are no cut-outs to do that. There's also not enough cable to run it from the side. We could run it straight up from the power supply, but that's messy. Instead, we'll unscrew some of the screws holding the mobo in place, near the socket, then thread the CPU power through the CPU socket cut-out on the mobo tray, then up into the power supply slot, letting the mobo stand-offs act as cable management space, before securing the mobo back down.

13 GRAPHICS CARD TIME

NOW YOU'RE ALL POWERED UP, it's time to fit your GPU. To do this, you'll first want to remove two of the PCIe covers located at the back of your rig. Find the two that are closest to the topmost PCIe slot. Use a screwdriver to remove them, and set them to one side. Then, take your GPU and carefully slot it into place, with the rear I/O pointing out toward the back of the case, from where you removed those PCIe covers earlier. Once that's done, push it into place until it clicks into the slot. Finally, secure it down with the two screws you removed from the PCIe bracket covers earlier, and that's all there is to it.

14 GPU POWER

SOME GRAPHICS CARDS need additional power, because although they draw power directly from the PCIe slot they're placed into, the higher-end cards demand more juice to run correctly. Don't worry if you forget, and you power on the system without it, because you'll receive a message on boot telling you to power down the machine and plug in the additional cables. PCIe power cables are usually labeled, and come as a daisy-chained plug. In our build, however, our card doesn't need any additional power. So, for us, it's simply a matter of tying the cables up, and putting them somewhere out of the way in the bottom of the chassis. Once this is done, you simply reattach all the panels you removed in step one, which are safely stored in your chassis box, and you're good to go.

Set Up Your Software

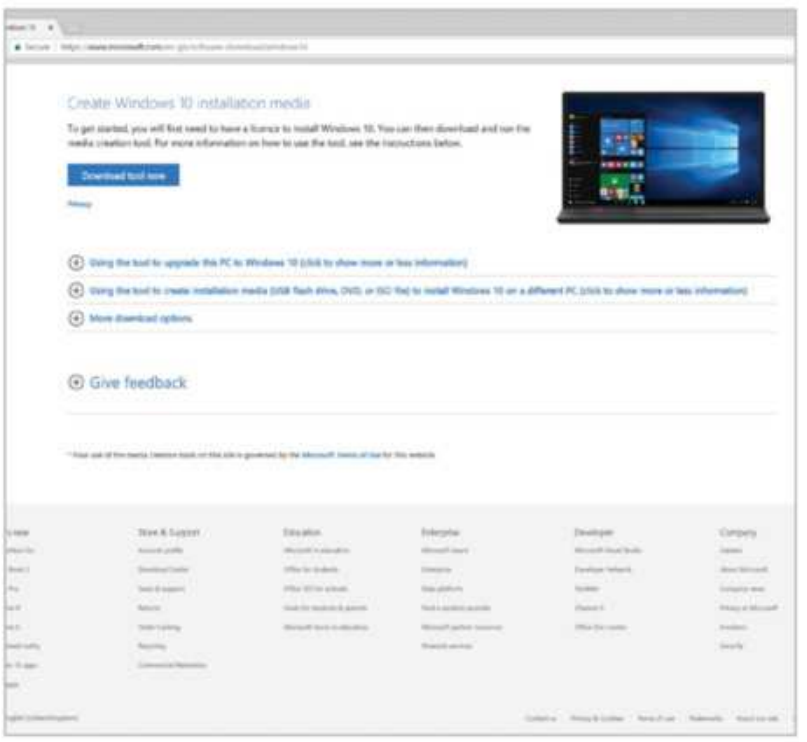
From BIOS to boot, follow our guide to installing your operating system, device drivers, and a selection of essential apps, one simple step at a time

YOU'VE MADE IT. You've got a brand new rig, and you're ready to kick some serious ass in those 1080p games. But how do you get there? How do you install an operating system on your new machine? You haven't installed an optical disc drive in your chassis, and you don't seem to have one laying around either, so where do you go from here? No need to worry—we've got your back. The last time we used one of those DVD readers was way back in 2016, and even then that was only to see whether the coverdisc of our friends over on the Linux titles would read properly. Spoiler: It did, then they trashed our DVD drive. Typical, right?

But enough waffle. You're here to install your OS of choice. For us, that's Windows 10. You could game on Linux, if you want, but because this is *Maximum PC*, not *Game Releases Two Years Later PC*, unfortunately (or fortunately, depending on your point of view), we're stuck with Microsoft.

1 BOOTABLE MEDIA STICK

FIRST THING YOU NEED to do is grab an 8GB USB stick, preferably 3.0, if you've got one. But, as this is mostly a one-time deal, it doesn't hugely matter. Then, on another system, with Windows already installed, you need to go to http://bit.ly/Win10MediaKit and hit the "Download tool now" button. This gives you an EXE file that you can then use to download and create a bootable USB stick. On MacOS or any Linux distro, you're given an ISO instead of this, so you have to use a third-party program, such as Etcher, to mount the ISO on the USB stick.



2 FIRST-TIME BOOT & BIOS

NOW YOU'VE GOT a bootable OS USB stick, you need to plug it into your new machine, add a keyboard and mouse, connect a screen to the GPU's rear I/O, and power the machine on. Hammer the Delete key as soon as you hit the power button, and keep hitting it until you enter the BIOS.

To install Windows, we need to tell the BIOS to boot from the USB stick. Although the location of the boot order varies from mobo to mobo, the procedure is very much the same. In our build, head to the BIOS menu on the top, go down to "Boot Option Priorities," click "Boot Option #1," and select the disk that's labeled "UEFI: Your USB Drive, Partition 1." Hit F10, and select "Save Configuration and Exit." The machine reboots into the USB stick.

You enter Windows Setup at this point. Choose your language, time, and keyboard layout, then hit "Next." Windows then asks for a Windows Activation key—you can either enter this here, or do it later by hitting the "I don't have a product key" button at the bottom. Next, you need to choose the version of Windows you want to install; for us, that's "Windows 10 Home x64." Accept the license agreement and hit "Next." Then, when prompted, hit "Custom Install," and choose your SSD as your primary drive. There are no names here, but each disk does specify its total size, enabling you to select the appropriate drive. Hit "Next." If it throws up an error, or there's a partition already there, delete the partition, and try again. Windows now installs. Once the system restarts, quickly pull out the USB stick, and let Windows finish the install. Now you can select the privacy options right for you, and either log in using your Microsoft profile, or create a localized account.

3 OF DESKTOPS & CHIPSETS

YOU'VE MADE IT to the desktop, so what's next? That depends on a few factors. Some motherboards support Ethernet connections automatically, while others require a driver to be installed before even connecting to any network. In our case, it's the latter. So, again on another system (or even on your Android phone, if you're in a pinch), head to your motherboard model's web page (Google your motherboard model—"Gigabyte B360M D3H," in our case—and choose the manufacturer's URL). Then click the "Support" or "Download" tabs, find the "LAN" subsection, and download the relevant driver. Finally, install that on your desktop, and it gives you access to the Internet.

Once this is done, you're going to want to install the remaining drivers. First up is the chipset. From the same website, download the latest version of the chipset, along with any other software, and install it directly on your new system. We recommend that you install the chipset first where possible, before anything else, such as RGB or utility applications provided by the manufacturer, to stop any incompatibilities from occurring.

4 INSTALL YOUR APPS

NOW YOU'LL WANT some regular apps on your rig. A quick starting point is that long-time industry favorite, Ninite. Head to https://ninite.com and pick the apps you'd like to install. There's a few we recommend off the bat: Chrome, LibreOffice, Notepad++, and 7Zip. You can also install things such as Skype and Steam if need be, but if, like us, you're a stickler for having all your Steam in a single location, it's arguably better to hold off on that one until later.

If you watch a lot of media, K-Lite Codecs is a good choice. It installs Media Player Classic, which can decode and play MKV video files, among other things. You also need GPU drivers. In our case, Google "Nvidia GeForce Drivers," and click the topmost link. In "Manual Driver Search," select your GPU and OS, hit "Start Search," then download and install the driver. You can opt out of installing GeForce Experience, but then you'll need to do this every few months; GeForce Experience auto-downloads driver updates, but you need to make an account, and give Nvidia some juicy advertising details (yeah, we're not fans).

5 UPDATE THE BIOS

NOW IT'S TIME to update your BIOS, and get everything ticking along smoothly. Depending on how long your motherboard has been sitting in a warehouse, you might not have the latest BIOS installed. BIOS updates typically improve stability, weed out bugs, such as Spectre and Meltdown, and can, in some cases, improve performance. Head back to your mobo's web page, and into "Support." Download the most recent BIOS update, and place it on your desktop. For a BIOS to read an update off storage, the BIOS update file needs to be placed on a memory stick or storage device that has been formatted to the FAT32 file system. Fortunately, your Windows 10 install stick we used earlier already has been.

Plug your Windows install stick into your system, create a new folder inside it called something like "BIOS Updates," take the BIOS update you downloaded, and extract it into this folder. Restart your machine and mash the Delete key to get back into the BIOS. This next step varies, depending on the motherboard (check your mobo manual). In our case, move the mouse to the bottom-right, and a pop-up menu appears. Select "Q Flash," then "Update BIOS," after which you need to find the BIOS folder you made earlier on your memory stick. Select the BIOS file in that folder, and hit the arrow to the right. Your system now starts updating the BIOS. It's imperative at this point that you do not reset or switch off your machine, or you could brick the entire board. Let it do what it has to; it may restart a few times. Once done, head back into the BIOS (we still have work to do).

6 PERFORMANCE TWEAKS

THERE ARE JUST a few performance options left to tweak in the BIOS. One of these steps can be ignored, but if you are a perfectionist, getting these last two things done will set your mind at ease, and ensure everything is running as it should be. Head back into the BIOS by smashing the Delete key on restart/startup. First, we'll enable the XMP (Extreme Memory Profile) settings, a pre-set list of specifications that your memory can and will run at, that are typically higher than the JEDEC standard. This means you can transfer more data to and from your memory faster for better performance in memory-intensive applications, such as archiving/zipping, and any photography or editing work you may do. For our Gigabyte board, enter the "Advanced Frequency Settings" option in the main menu, then go down to the "Extreme Memory Profile" menu, press Enter, and choose "Profile 1." This enables the correct timings and frequency for your memory.

You might also want to take a look at fan curves while you're here. You can control these with in-desktop apps, but we always find that BIOS configuration works best, and works from startup. For our motherboard, those settings are found at the bottom of the main BIOS menu. Have a tinker, and find a setup that works for you. That's all there is to it. Then hit F10, save, and exit, and there you have it—one fully working, ready-to-go system.

1 **Hiding any excess cables under the hard drive caddy here is ideal for keeping things tidy, as long as you don't have more than one 3.5-inch drive, of course.**

2 **There are no intake fans with this build—adding two 120mms in the front of the rig would keep temperatures down, especially during the hot summer months.**

3 **If you're going to upgrade your processor at a later date, remember to get a beefier cooler; this slimline stock one won't cut it.**

4 **We love a GPU that draws power solely from the PCIe bus, although admittedly, it won't be as fast as some of its higher-spec buddies.**

HALF A GRAND OF GAMING GOODNESS

THERE YOU HAVE IT: your very own budget 1080p gaming machine. It's versatile, compact, easy to build, and looks darn good, given the limited funds we had. We could have whacked in an Intel Core i3 quad-core part or a GTX 1060 to bolster performance—two very smart moves—but that would mean a bigger budget, and not everyone has that kind of cash lying about.

We managed to stick to our $500 hardware budget fairly well. In fact, if you're interested in checking out where we sourced the parts for this build, head to https://pcpartpicker.com/list/3YQfFt for a full breakdown. Don't worry, there are no affiliates links or codes there, least not from us, although we're pretty sure that's how PCPartPicker makes its money. Anyway, you can see what we chose, at what price, and where we'd pick it up from.

But enough of that—was this build a success? Yes. It was never going to compete with our zero-point—that's a $1,100 machine packing a six-core processor, 16GB of DDR4, a PCIe SSD, and an Nvidia GTX 1060, after all—but for the price, it actually held its ratings fairly well, and despite the lackluster computational performance, the effect on real-world feel and use is slim to minimal.

In game, it's rather different, of course, with most of our tests being almost unplayable in certain circumstances, but this is where we need to get a little granular and explain the whole purpose of our build. With a system like this, you need to be a tweaker. Not necessarily of hardware or overclocking, but of graphical settings. From past experience, we know that when gaming, there are two effects that take up the majority of your processing power: antialiasing and shadows. Now, in our scenario, you'd be gaming on a 1080p 24-inch panel, so turning off AA in its entirety is a bad idea; reducing it, however, is less so. But let's give you some metrics here.

In our Ultra preset benchmark test for *Warhammer II,* we managed 27fps. With a few minor tweaks, shadows reduced to minimal, a slight decrease from Ultra to Medium in various textures, and a reduction in foliage/tree quality, we managed 38fps, with minimal impact on overall texture quality. Take that same logic across to *Rise of the Tomb Raider,* and we managed 52fps. Amazingly, there's a setting that renders each individual strand of hair on Lara's head; although it looks breathtaking, during the middle of a game, it's not something we particularly notice.

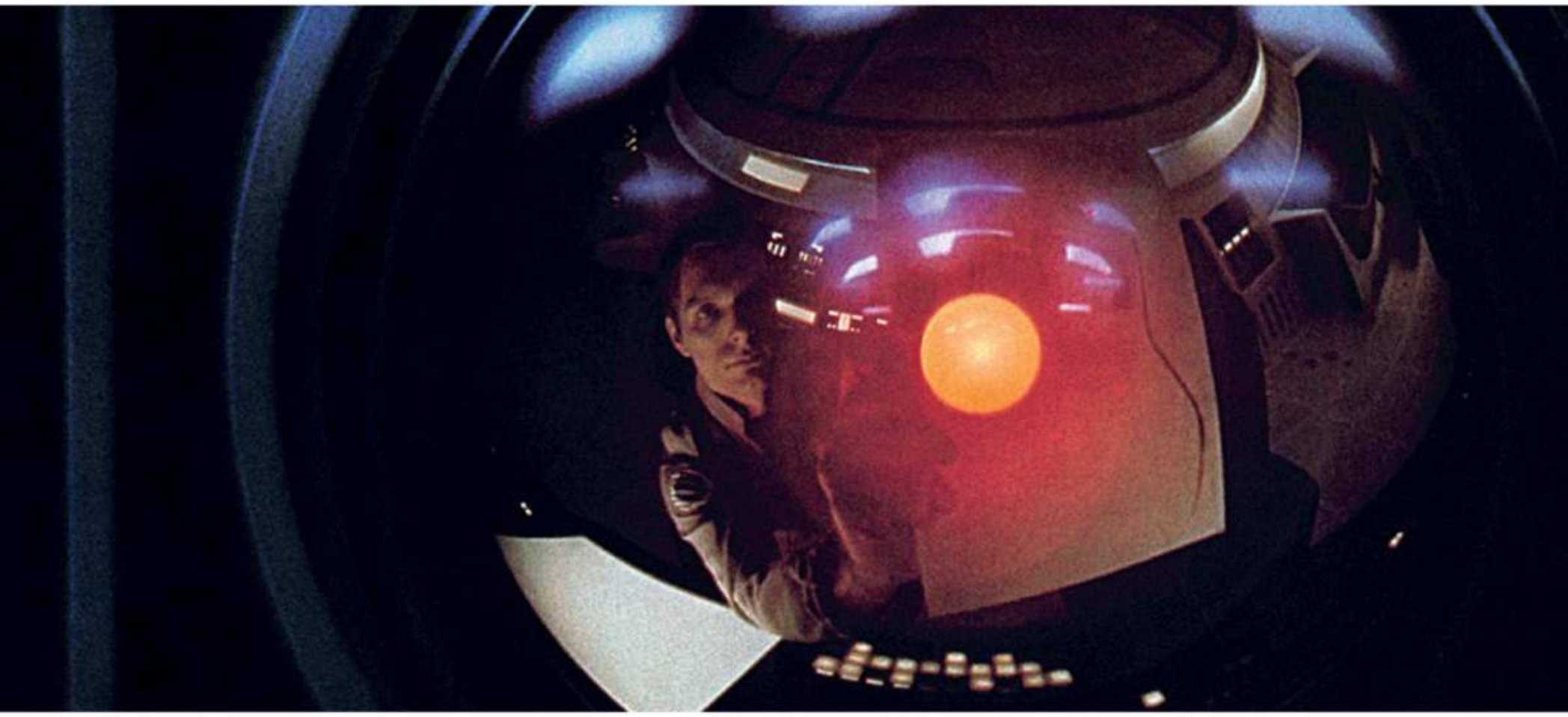
Perhaps the biggest difference was in *Ghost Recon.* A demanding game at the best of times, dropping the graphical profile down from Ultra to High, and again adjusting the shadow quality (not disabling it entirely), bumped up frame rates from 5 all the way up to 40fps. That's a 700 percent increase just by tweaking a profile. OK, it's a bit more messing about before playing, but even at the high end, with GTX 1080 Tis and Titans, you still go through the same process anyway, so what's so different down here at the $500 budget?

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	412 (-64%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	494 (-85%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	476 (-72%)
Rise of the Tomb Raider (fps)	60	35 (-42%)
Total War: Warhammer II (fps)	46	27 (-41%)
Tom Clancy's Ghost Recon: Wildlands (Avg fps)	39	5 (-87%)
3DMark: Fire Strike (Index)	11,101	5,880 (-47%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1080p at the highest graphical profile.



Machine learning is much more than a set

Machine learning is absolutely everywhere now; it's the computing zeitgeist. Digital assistants use it to translate speech. Facebook uses it to automatically tag images (DeepFace has a claimed accuracy of 97.25 percent). Uber uses it to calculate arrive times and pickup locations. Amazon, Spotify, and Netflix use it to select the recommendations they serve to you. Google introduced RankBrain to its search engine in 2015, to untangle query semantics, Gmail has its Smart Reply service, and last year, Google Maps started using machine learning to extract street names and house numbers from images.

These are just the tip of the iceberg. Behind the scenes, big business has taken machine learning to heart. Financial institutions use it to track market trends, calculate risks, and delve into the streams of financial data. The race to the self-driving car is being powered by machine learning. Any business that is trying to see patterns in the untidy mass of data humans create can make some use of machine learning, from the FBI, medical research, and insurance down. Currently, the five biggest companies by market value in the world are Apple, Amazon, Alphabet (Google), Microsoft, and Facebook. Every one of these has made massive investments in machine learning, and has access to the kind of big data its effective use requires.

One thing to remember is that machine learning and artificial intelligence are two different things. Artificial intelligence is a device, program, or system that appears "smart," one that can act and react in a quasi-human way. How this is achieved is a separate thing. Machine learning is a method that AI can employ to appear smart but, more importantly, to learn as it operates. It is this ability to adapt that is causing the revolution.

PROGRAMING VERSUS LEARNING

A computer program is a set of instructions, all neat and logical. Given an input, you can trace the data through the program's algorithms, and accurately predict the output. This is the traditional way that computers work—inflexible, and quite unlike the real world. Each task requires

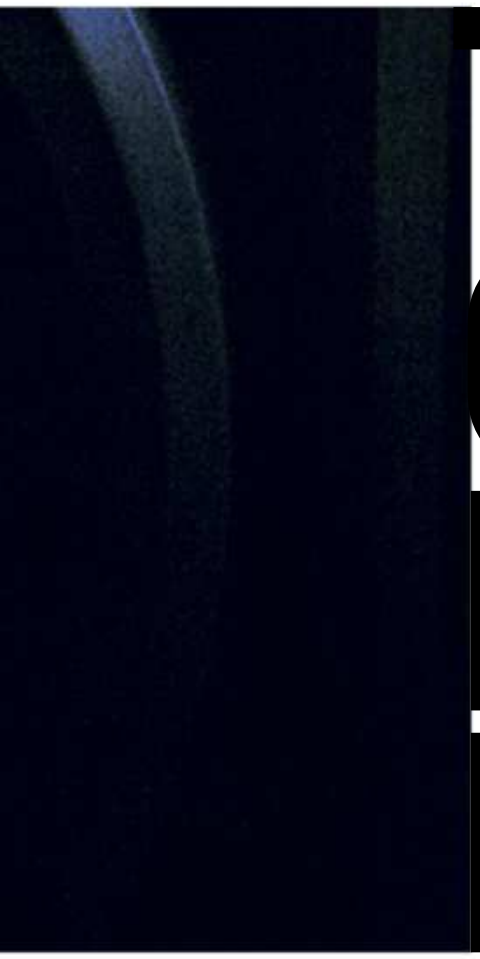
TRY IT FOR YOURSELF

DEEPDREAM
http://deepdreamgenerator.com
Neural networks see all sorts of weird patterns in images, like the way we see faces in clouds. DeepDream uses algorithmic pareidolia to bring these to life—a vivid and psychedelic one. As an image is processed multiple times, strange things appear, as previously unseen patterns are drawn out. Bizarre.

MITSUKU
http://pandorabots.com/mitsuku
This chatbot has won the Loebner Prize Turing Test three times. She can chat on a number of platforms, including Messenger, Twitch, and Telegram, or just plain web chat. Fun for a while, although you don't have to stray far to confuse her.

MICROSOFT CAPTIONBOT
www.captionbot.ai
Upload an image and this bot writes a caption for you. This one has been around for a while, so it should have had a good bit of training. It's still generally only average, though—you won't have to try too hard to fool it. When launched, its inaccuracy, and comical guesswork lead to a slew of pranks.

IMAGE-TO-IMAGE
http://affinelayer.com/pixsrv/
This takes your crude attempts at drawing cats, buildings, shoes, or handbags, and through the magic of a trained machine learning engine, generates artificial photographic images of the results, which range from creepy to pretty good, especially the buildings. The better your drawing, the better the result.



THE RISE OF THE LEARNING MACHINES

of clever algorithms; it's changing everything

the program to be written to deal with that specific task.

Machine learning is a way to create a program that apes the human brain, rather than a calculating engine. Instead of trying to program for every eventuality, every task, every type of data, you create a machine that thinks more like a human. Enter the concept of the neural network: a system designed to mimic the fluid way the human brain creates and changes its internal connections as it learns.

It all sounds wonderfully modern and fresh, only it isn't. Like many programing concepts, it's actually not that new. The practical capabilities of machines have long lagged behind ideas. The first recognizable computer algorithms were written around 1837, at a time when hardware was an unfinished mass of cogs and gears.

Machine learning isn't quite that old; the idea is generally credited to Arthur Samuel, who coined the term "machine learning" in 1959, and helped write a checkers-playing program that learned from its mistakes. Its roots are deeper still, though. Back in 1943, neurophysiologist Warren McCulloch and mathematician Walter Pitts described how a neural network operates, and modeled one using electrical circuits. In 1949, the psychologist Donald Hebb gave us Hebb's Law: "Neurons that fire together, wire together," fundamental to the way internal connections are reinforced by learning.

Progress was slow, mainly due to the technical limitations of available hardware, and the lack of key algorithms, such as backpropagation (used to calculate weights, more later). Despite decades of research and theory, it took until the 1990s before we had widespread useable machine learning programs, and it took until the 2010s before large neural networks were feasible.

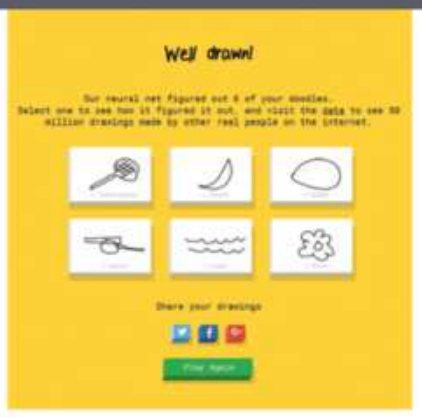
A neural network consists of a set of input and output units. Between these is a grid of artificial neurons, called nodes. These are arranged into layers, the output from one layer feeding into the next. Connections are assigned a weight, a level of influence, which changes as the network learns. Each node is fed data, performs an operation, and sends the result on, according to the weight.

A neural network needs teaching (OK, not all of them, more later). A common

EXPERIMENTS WITH GOOGLE

http://experiments.withgoogle.com

This site features dozens of interactive machine learning experiments, which have been put together by Google's engineers over the years. These include data mapped out in new ways, tricks with images, handwriting, text, sounds, and more.



This is Quickdraw, from Experiments with Google.

TENSORFIRE

http://tenso.rs/demos/fast-neural-style/

Upload an image to this site, and a neural network will transform it into a work of art—or rather, an interesting stylized image from a selection of different methods. The results are generated surprisingly quickly, and can actually look very good.

TENSORFLOW PLAYGROUND

http://playground.tensorflow.org

A simulated neural network on a browser page—take a quick look at this if you would like to see how complicated machine learning is, despite the relatively simple underlying theory, even using a small and simple network. *Warning*: contains math.

use is pattern recognition in images. So, for example, if you feed your network an image, labeled as "contains cat," the network knows the desired output, so the configuration of the node weighting is simple. Then you feed in more images: black cats, ginger cats, running cats, sleeping cats, partial images, and images without cats. Each time, the connection weighting needs to be adjusted, so that the correct output is maintained, not only for the current image, but for all previous ones, too. As the network learns, the weight of each connection is established between the nodes.

A system of pattern recognition now emerges within the network—it will learn the outline of a cat, the position of its eyes and ears, and so forth. Eventually, you will be able to feed in an image without revealing the correct output, and the system will correctly see, or not see, a cat. This is the classification model; it attempts to predict one or more fixed outcomes. The regression model is similar, but the output is a continuous variable, say a dollar value, or floating point number.

The magic of a neural network is that the internal process is hidden. You may have created it, but once trained to a task, you don't actually know what the weights are at each node. It may be using the shape of the cat's eye to identify them, or it may not, you don't really know exactly how it achieves the results it does, which is a long way from the fixed logic of a traditional program.

Nvidia trained this deep learning image noise reduction system with 50,000 images. The most impressive part is that it was trained only using corrupted images.

There is an obvious drawback: It is fallible. There is a level of accuracy, and there is never the guarantee of 100 percent; an unusual concept for a computer program, where output errors are seen as bugs, errors in the code logic that can be corrected. A neural network, in becoming more human, has gained our ability to err, too. This isn't too much of a issue when we are tagging pictures of cats for Facebook, but is something to bear in mind when designing a system for a self-driving car.

There are other issues, too. It's sometimes difficult to work out why one result outranks another, as so much of it is hidden in the internal weighting. This can also make it difficult to fine-tune. There has reportedly been much internal discussion at Google over the relative merits of machine learning over its rivals for ranking search results and advert targeting—it doesn't lend itself to a quick tweak when you want to push one result over another.

A simple neural network can run on a handful of nodes. Detailed work requires something a little larger. Facebook's DeepFace runs on nine layers and has 120 million connection weights. For contrast, the human brain is widely quoted as having 100 billion neurons, although a recent, and rather grisly, experiment involving sampling a human brain soup revealed

This little bird was generated by a Microsoft research project called the Drawing Bot. It was created from a text caption: "This bird is red with white and has a very short beak."

TROUBLE WITH REALITY

We are used to digital fakery, from Photoshopped fashion shoots to blockbuster CGI effects—we know all is not as it appears. The fakery may not be new, but the ease and accuracy with which it can be done using a machine learning system is alarming.

Witness deepfake; this emerged in the fall of 2017, when a number of pornographic videos, apparently featuring celebrities, appeared. All artificial. Deepfake uses a neural network to superimpose faces on to figures in videos. It's trained using multiple images of the target victim, and can operate in near real time. It was soon followed by FakeApp, a simple application version of which required little programing skill. Now it became possible to easily subvert the verisimilitude of videos shared online.

Despite being banned on a number of social media platforms, deepfake is still widespread. It has been used to create political satire, plain mockery, and put to more devious and hurtful uses, as well as putting the face of Nicolas Cage on famous movie clips for no good reason at all, other than to create an Internet meme.

There are limits—while pretty impressive, close inspection does reveal oddities. But, if you're scanning through video clips on your phone, a deepfake fake would readily slip by unnoticed. These are dangerous waters, and they make it more important than

This stop sign, created by researchers at the University of Washington, fools self-driving cars—the added stickers are designed to throw the image recognition off balance.

a figure of 86 billion. Each is connected to somewhere between 1,000 and 10,000 other neurons (nobody is really sure; 7,000 is often cited as a fair guess). This puts the number of connections into the trillions, more than there are stars in the Milky Way. Wow. The largest artificial systems built so far touch one billion connections, and these have been short-lived research projects. We still have a long way to go.

As you might have guessed, we've stuck to the basics here. Machine learning is not all neural networks, for starters; support vector machines are another popular method, which are trained in a similar way, but use a different mathematical model internally. These are simpler, don't require huge amounts of computational power or big data sets, and the internal workings are more open to examination. But they don't have the power or scale of a neural network.

Machine learning is a subject that becomes complicated very quickly as you delve deeper. We can't even begin to list the basic machine learning methodologies; there are over 50. These use a whole slew of statistical analysis tools, decision tree algorithms, dimension reduction, regression analysis, and heaps more. This is high-grade math.

As well as the supervised learning outlined, there are semi-supervised systems, which use a minimum of labeled data, and fully unsupervised systems. These work with no labels at all; you just feed in raw data, and let the algorithms go to work. From these emerge patterns of clusters and associations that might not be obvious any other way.

You can only train a system if you know the output criteria you're looking for. If you didn't know you were looking for cats, you can't train a system to find them. Unsupervised systems are useful for creating data labels, which can then be fed back into supervised systems; for example, finding a cluster of images that appear to contain the same object. They are also good at finding anomalies in data, ideal for security systems looking for signs of fraud or hacking, but when you have no idea where or how these are going to be made.

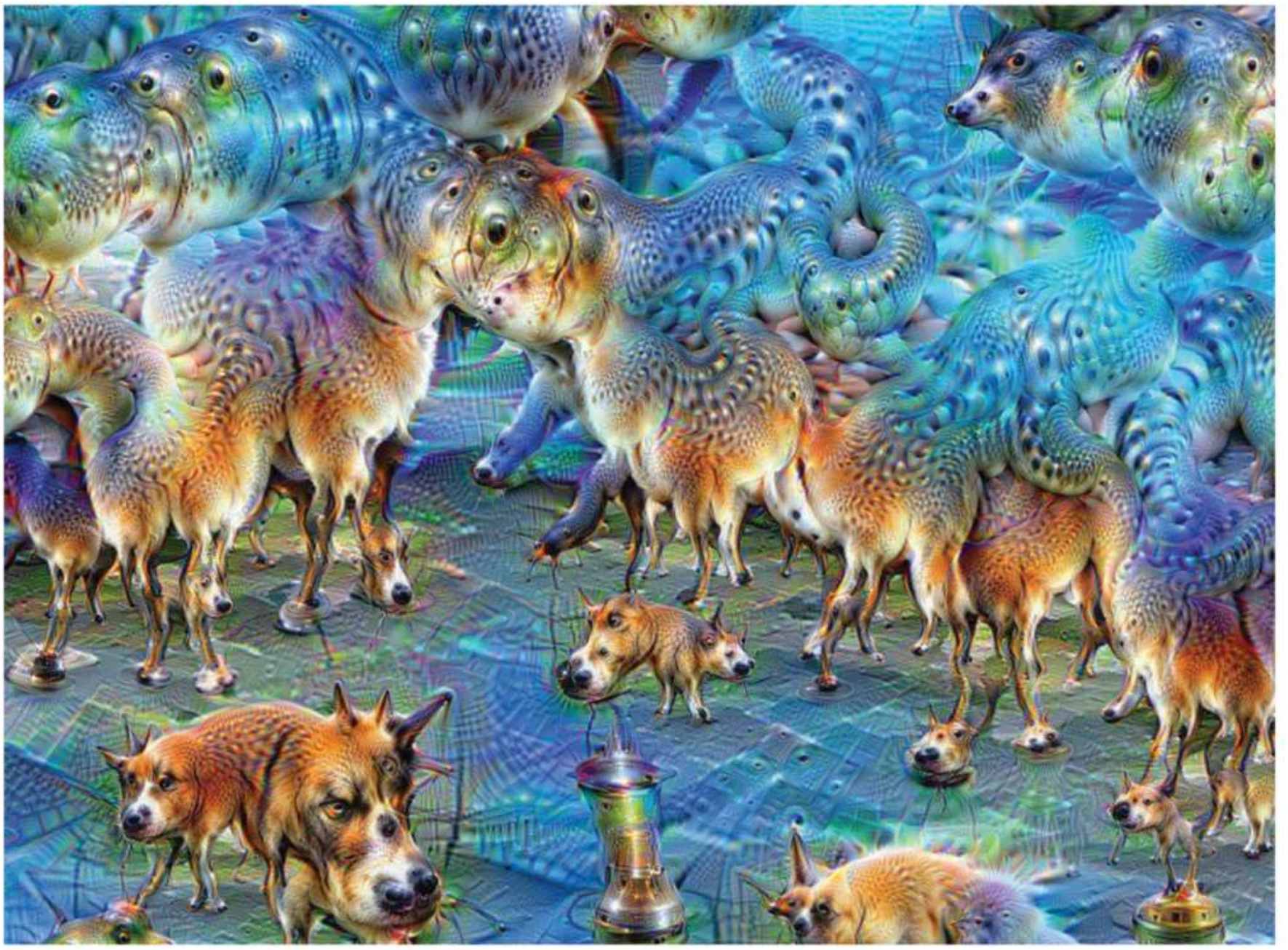
Another much-used machine learning buzzword is deep learning, essentially just used to describe large and multi-layered neural networks. In image recognition systems, for example, layers may be used to divide images into areas or blocks that may be objects; the next layer may try to define edges; and further layers identify specific shapes, ending with a trainable output. The more layers, the greater the sophistication, as the input is broken down into an increasingly abstract representation of the data. Simple neural networks may only have a few layers; a deep learning

A team at MIT has created RF-Pose, a system that uses wireless signals to track people, even through walls. It's trained using a camera and radio signals.

This deepfake president was created by Jordan Peele and Jonah Peretti to illustrate deepfake's dangers; it follows Peretti's voice.

ever to always trace the source of something before you give it credence—unfortunately, something that is easy to preach, but not so simple to follow in practice.

There's more to come: Deep Video Portraits, for example. These go further, and enable you to use the movements and facial expressions of one person using the head of another. Now you can have your fakes move and express themselves anyway you wish, rather than merely being superimposed on to a target video. Full digital avatars of anyone we want made possible from your desktop can't be that far away. The democratization of Hollywood CGI effects perhaps, but not without ramifications to trust.



If you train a neural network to identify dogs, then process the same image 50 times, this is the result; here thanks to Google's DeepDream.

system can run to three figures. They scale well, but do require significant resources.

What machine learning needs to thrive is access to a lot of data. This has now been provided, thanks to the Internet, by us. We've typed in untold search requests, emails, and blogs, uploaded millions upon millions of images and videos, created purchase histories, travel histories, we've shared things we like, what we've seen, heard, and read, and more. This is big data, a set large enough to reveal underlying patterns, associations, and behaviors. We've been feeding data into the Internet for years now, and an awful lot of that is sitting in data farms ripe for processing.

The other thing it requires is processing power. The GPU proved to be just what the systems needed for the simple but repetitive operations, and now we have dedicated hardware from Google and IBM, with Intel and others to follow (see box below). Wireless Internet is in our homes, and the hardware required to connect devices is cheap and plentiful. Add these factors together, and we have the perfect storm for an explosion in machine learning.

We have reached the point where it has become easy and relatively cheap to add machine learning voice control or gesture

THE HARDWARE RACE IS ON

You can run machine learning applications on pretty much any processor. However, it thrives best on a chip that can churn out huge numbers of simple calculations with a low power consumption, a similar task to cryptocurrency mining. Traditional x86 processors aren't particularly efficient at this. A popular choice has been Nvidia's Tesla GPU, hardware that lends itself very nicely to the task. This has grabbed a decent slice of the emerging market for servers running neural networks. However, things are changing rapidly.

Google has decided to go all-in and develop its own hardware. In 2016, we learned of the Tensor Processing Unit, designed specifically for neural networks, and initially a fairly crude 8-bit chip. The next year, it divulged the second-generation version, with much improved capabilities, managing 45 Tflops. In May this year, a third-generation chip was announced, which is twice as powerful. Google is ramping up fast. Google's TPUs are not available commercially, but the company will let you rent access via the cloud. Intel, meanwhile, has the Nervana chip due next year, the first fruits of its acquisition of Nervana Systems in 2016. This is a purpose-built machine learning chip. It has promoted the Xeon Phi, a x86 multicore server chip, as machine learning hardware, but it was always something of a stopgap. IBM has the Power9 chip, available to third parties

recognition to something as mundane as your television. Modern sets are already connected to your wireless hub; it's a simple matter to route your voice command or images to a server running one of the popular machine learning frameworks—there are dozens, including Google's TensorFlow and Amazon's Machine Learning. Here, a neural network quickly translates your command and routes it back to your television. And as if by magic, you can instruct your television to turn down the volume by voice or movement, rather than be bothered to press a button. Ten years ago, this would have been difficult and impressive; now, it's nothing unusual.

We've become acclimatized to virtual or digital assistants quickly, too. These have only been on the general market since 2011, the first being Apple's Siri on the iPhone 4S. Last year, the market for smart speakers grew by over 100 percent, and they were Amazon's best-selling item. By the end of this year, it's estimated that there will be over 100 million in people's homes, and by the end of 2020, there will be over 225 million, all listening for the magic words.

These digital assistants won't stay in our homes; there are plans to bring them into your car, and your office, as well as build them into other devices—a refrigerator you can talk to, anyone? These assistants won't just talk to you, either. This year, Google demonstrated Google Duplex, which will make phone calls for you. Currently, it can only cope with mundane tasks, such as booking a reservation at a restaurant. The system has a natural-sounding voice, and even adds "ums" and "ers." Add a neural network system to answer calls, and it won't be long before we can have our digital assistant call their digital assistant.

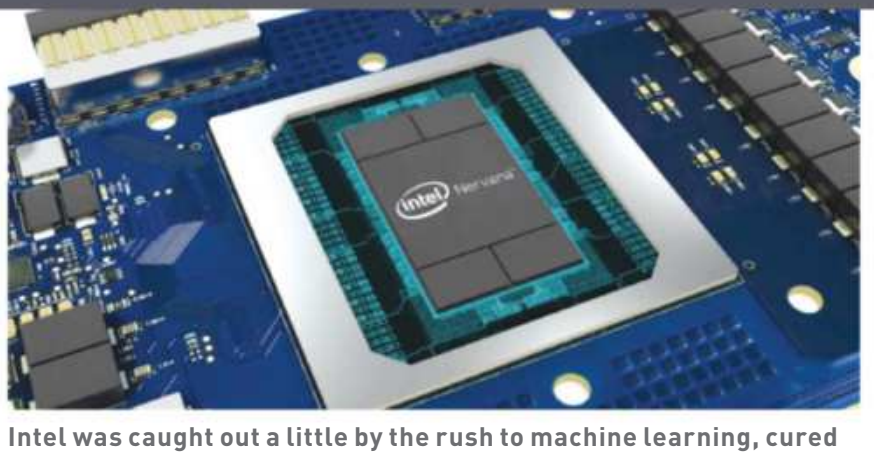
One of the biggest, and most public, applications of machine learning in the real world is the self-driving car. This little project is currently soaking up billions of dollars of research funding, and has a dozen or more of the world's biggest firms chasing it, from giants such as Google and traditional car companies such as Ford, to a new generation of firms, including Tesla and Uber. It is a huge test of the technology, and results have been generally positive, although not without mishap.

The kind of things that can throw a system are myriad, and often unexpected. While testing its system in Australia, Volvo found that it was confused by kangaroos, unable to work out which way they were going. Apparently, the hopping was registered as both moving toward and away from the vehicle. In India, Tatra's system is struggling to cope with the strange variety of mixed traffic on the roads. Auto-rickshaws have proved a special problem, as they are

Feed thousands of images into a neural network, and you can create lifelike, but artificial, images. These were generated by Nvidia using a GAN, Generative Adversarial Network.

Adobe's upcoming Cloak feature can remove selected elements from videos. No more painful frame-by-frame editing required, and the results are impressive.

The Super aEgis II Sentry gun can operate autonomously, tracking targets up to 2km.



Intel was caught out a little by the rush to machine learning, cured by a rapid series of acquisitions, including Nervana Systems.

or via the IBM cloud services. The world's fastest computer, Summit, contains 9,216 of them.

Elsewhere, Apple has its neural engine, part of the A11 processor for its iPhone. Amazon has a department working on AI designs, although it is unlikely to produce its own hardware. ARM is also developing new ground-up specialist neural network hardware designs. Qualcomm has its Neural Processing Engine SDK for its Snapdragon chips, too.

There are also said to be 40 or more start-up companies jumping on to this particular hardware bandwagon. Machine learning has prompted a hardware arms race that, in the long term, could be as important as the x86 race.

These comical cars have been autonomously trundling around the Google campus for a while. Despite the controlled conditions and low speeds, it has not gone without incident.

A self-driving Jaguar iPace car from Waymo (part of Alphabet); these are starting tests in San Francisco.

often decorated and customized to such a level that they become unidentifiable.

Despite technical hurdles, the race to autonomous cars appears unstoppable. There are dozens of test programs on public roads, and Ford plans to launch a fully autonomous car by 2021, "in scale." Early cars will be expensive, and probably rented out for use as a taxi service, rather than personal transport. They also look likely to be initially limited to carefully mapped locations. We can be sure of a fuss—crashes by self-driving cars still make the news even now, and the legal implications are interesting—but they are coming to a road near you soon.

Machine learning will soon be endemic, humming away in the background, helping to run virtually every institution with a network connection, banks and governments, down to bots in our games, and assistants that suggest we order a pizza because an algorithm has calculated that our behavior model indicates this as a likely response to the four-hour gaming session it detected. You never know, perhaps one day we will have a version of Windows that can detect and correct bugs as it operates.

A brave new world? Not a flattering analogy perhaps, but there is a hint of dystopia here. Alongside patently worthy applications, such as medical research, and useful tools, there is going to be a mountain of marketing. Our digital footprint is going to be sifted and sorted, as companies look for patterns and clusters, trying to predict what we want, where we want it, and when we want it. You are the customer, but you will also become the product.

Our rights to online privacy are still being hammered out, too. How much of your life do you want processed by deep learning machines? Because there is a whole generation growing up that sees a smartphone as an essential item, and appears happy to share a detailed view of their lives online. The ramifications for social media are already becoming clear, as increasingly sophisticated bots learn to mimic real people. Twitter and Facebook are already deleting millions of accounts a year. Governments and organizations have always practiced social manipulation in one form or another, from slogans and billboards upward. Integrated machine learning systems bring a whole new armory into play.

At some point, boundaries will have to be drawn. Some of them rather important. It looks as though we are going to have to accept that people will occasionally be run down by autonomous cars, but what about being shot by an autonomous military machine? These are already out there (see boxout below). Are we getting too dark now? Probably. Like any tool we invent, it is up to us how it is used. However "smart" machines become, they are still kinda stupid, too. A three-year-old child

AUTONOMOUS DEATH

If there seems to be an arms race in using machine learning in the civilian world, then you know there's one taking place in the military one as well. The US military has been using remote-controlled machines and semi-autonomous hardware for years, but we're now on the cusp of death by fully autonomous machines, known as LAWS, Lethal Autonomous Weapons Systems. Current systems only require human input for the final order to fire, although certain defensive systems are exempt—missile defense systems, such as the Phalanx, for example.

Many programers and researchers involved in machine learning have boycotted institutions and projects with military connections. Google has pledged not to work on any military projects, as has Elon Musk, but this won't really dent the research by much. Russia is deploying automated gun and missile systems to defend its bases and oil pipelines, and has developed the heavily armed Uran-9 drone tank. It has also publicly said that it will ignore any future ban on LAWS. Are we ready to be killed by an algorithm? The United Nations is currently considering a ban on any weapons that can kill without human intervention; however, the talks are being delayed by the usual squabbling and objections. It might like to hurry, though; the Russians are not alone—the South Korean arms company Dodamm is already selling gun turrets that

doesn't mistake a picture of a cake for one of a dog, an error that even the best image recognition system can make.

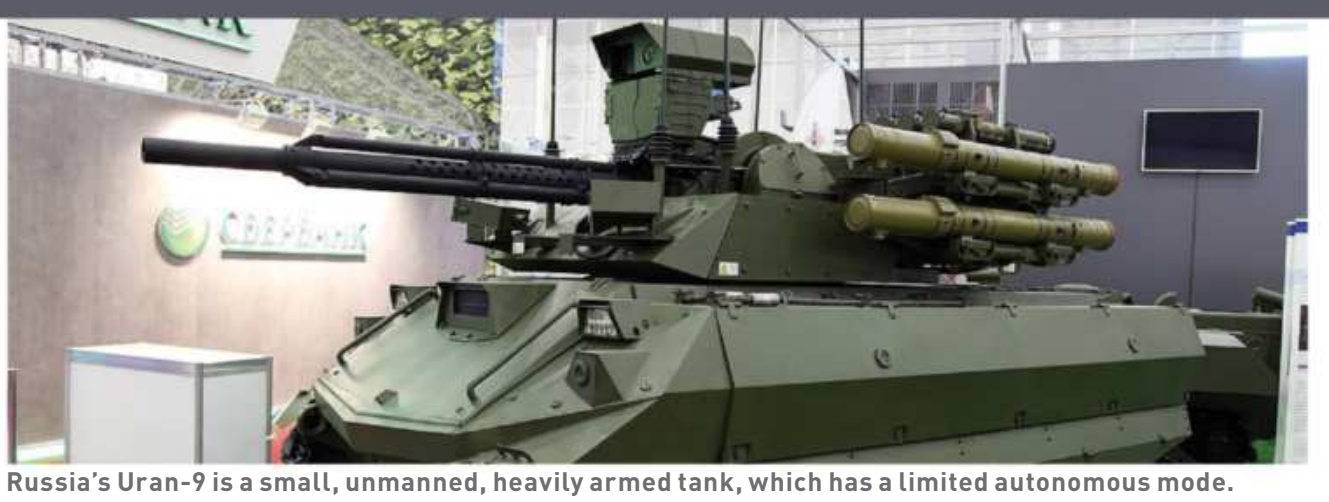
Many current machine learning projects have a narrow field. They are aimed at specific problems with limited goals: improving search engines results or guiding a car through traffic. The next step is a more generalized approach, where common sense and an understanding of human behavior and interaction are the target. Machines that don't just talk to order food for us, but can carry out a conversation that you can enjoy, too.

The world of human cognitive development is providing clues. We learn not only through trial and error, but guided by a set of internal instincts, nature, and nurture. Among the researchers in this new field is Intelligence Quest, a group based at MIT, and the Allen Institute for Artificial Intelligence. The next generation of machine learning systems should be able to react to the chaotic and unpredictable human world with more of that most human

Using machine learning to study all of Rembrandt's paintings, a team in the Netherlands generated this: "The Next Rembrandt." It's completely new, but unmistakably in his style.

of qualities: common sense. So when it sees a cake shaped like a dog, it won't be fooled.

Soon, we may look back at the "dumb" computers of the recent past, with their inflexible logic, with some amusement. In the 1980s, John Gage of Sun Microsystems coined the phrase, "The network is the computer." He was right, but it took years to sink in. Today, we view any unconnected machine as crippled. Perhaps we could now add one word to that phrase: "The neural network is the computer." –CHRIS LLOYD



Russia's Uran-9 is a small, unmanned, heavily armed tank, which has a limited autonomous mode.

are technically capable of fully autonomous operation, and are already being deployed along the border with North Korea, and in the Middle East. The concern is that if such weapons are not restricted, there will be an arms race, as each of the big powers scrambles to keep ahead. Once such systems are developed, it will be very difficult to go back.

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THE FUTURE OF WI-FI

Let's sail the wireless waves in pursuit of fast bonded channels and chests full of QAM

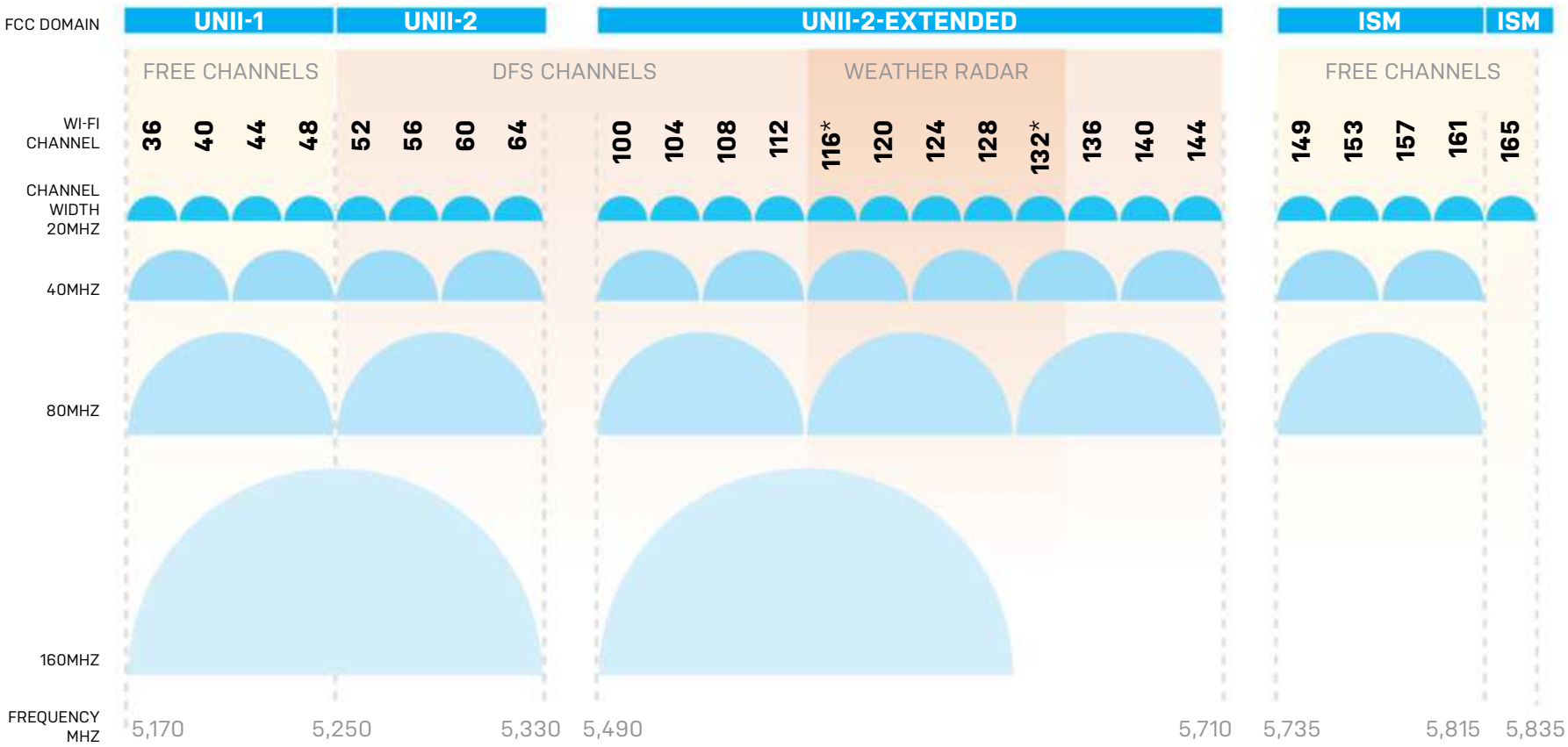
BY NEIL MOHR

HERE WE ARE AGAIN, unpacking a hopelessly complex series of standards in the pursuit of knowledge. We like to call it fun. For this issue's outing, we're looking at wireless networking. Not the frilly protocol level—that's way too neat—but the hardware and signaling levels, the nuts and bolts that enable routers and adapters to communicate with each other, and do so now at enormous speeds.

While once you might have been thrilled to get 2,400 bits of data per second down your dial-up phone line—literally seeing the bytes of data appearing on the screen, taking agonizing seconds—now, single-digit megabytes per second speeds simply aren't good enough for our wireless connections. So, we're going to delve into the 802.11 wireless standard, explaining the basics of how digital data can be sent over radio frequencies with various modulations, and how each evolution of the standard introduced new enhancements and so greater throughput, alongside how knowing all of these esoteric details can enable you to get even more from your own networks.

We'll literally start at "a" and end at "ax," we'll see how international standards helped create a unified worldwide system, how non-conforming releases broke the market for themselves, and how smart devices are improving reliability over raw speed. There is, of course, some head-splitting physics, but also a lot of common sense developments. So, let's see how wireless went from the unreliable 1Mb/s slow lane to the madness of 9,600Mb/s throughput.

5GHZ CHANNEL ALLOCATION



*Channels 116 and 132 are Doppler radar channels that may be used in some cases.

WIRELESS NETWORKS have been an utter revolution in the world of technology. Removing the need for any sort of wire to access networked data has propelled personal use, boosted businesses, and sparked entire new categories of devices, including the "Insecure-net Of Things"—we're not apologizing for that, it's true—among many others. Some of us old folk have been around long enough to remember coaxial-based 10Base2 networks, never mind the first 802.11 1Mb/s-capable efforts at wireless networking.

But what has changed to enable the same radio waves of the late '90s, which struggled with 1Mb/s, to expand and be capable of shifting supposedly 9,600Mb/s in 2018? To answer that, we're going to go back to basics, break out the slide rules, and knuckle down to some classic telecommunication theory.

So we know where we're starting from, everything we're talking about here is taking place on a standard sine wave. A wave has a wavelength, which describes how long it takes to repeat each full wave, which starts at a zero point, goes up to one, back down through the zero point to minus one, and back up to the zero point. It has an amplitude, which describes how big the peak is, like a volume level. The final measure is its "phase," which describes where the wave is starting from—at the top of a wave, the bottom, middle, or something in between.

All the channels available at 5GHz in the United States.

Pesky radar.

The specific wavelength of Wi-Fi itself is one of two (see the boxout opposite for more details), but the short answer is 2.4GHz or 5GHz. These are then broken down into subfrequencies called channels. If you want to avoid interference from other nearby transmitters, you need to be on separate channels.

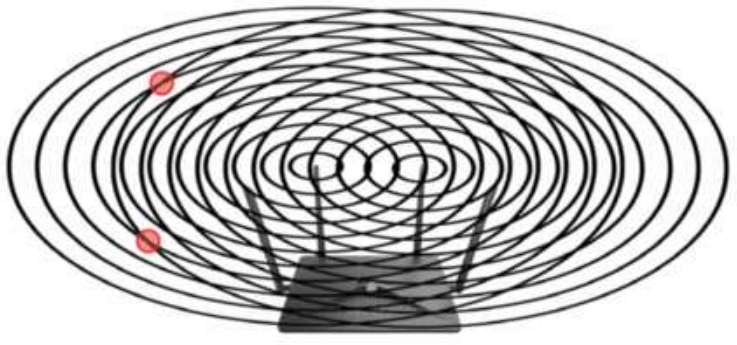
Depending on where in the world you are, the number of available channels varies. However, it tends to be that 2.4GHz has far fewer, up to a maximum of 14. The issue is that the way these are allocated means they overlap frequency bands, and the practical outcome is there are typically only four frequency-distinct channels—in the USA, it's just three.

At 5GHz, the channel situation tends to be better, especially in the United States—there are nine open distinct channels right off the mark. Unlike at 2.4GHz, they are all frequency-distinct. There are a further 12 channels licensed under Dynamic Frequency Selection; basically, some radars (often used for weather stations) operate in the 5GHz band, and these get priority. When a router is powered, it scans these channels, and if it detects a radar operating, it won't use that channel. If at any time during use it detects a radar, it ceases use of that channel within 10 seconds, and leaves it free for 30 minutes, before rescanning.

Either way, that's a far higher number of potential channels for use (21), though things do get more complex when multiple channels are bonded together. We'll go into channels in more depth when we cover MIMO, because they become important for multiple streams.

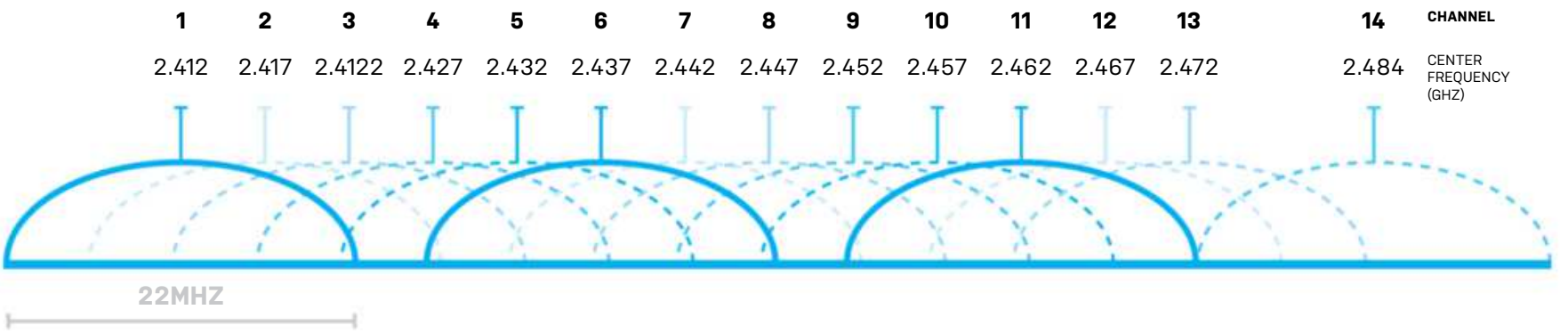
So, we're getting there in terms of knowing some of the basic elements of a wireless signal. The next key element to clear out of the way is: How do the router and devices know when to transmit and receive data? We're not going into depth on this, and it's a real nuts-and-bolts component, but Wi-Fi uses a protocol called Carrier Sense Multiple Access with Collision Avoidance, or CSMA/CA. It's a half-duplex system, so either end can only receive or transmit, not both. It's a robust system, using acknowledge

Using two antennas beamforming can move constructive areas of interference to double transmit power.

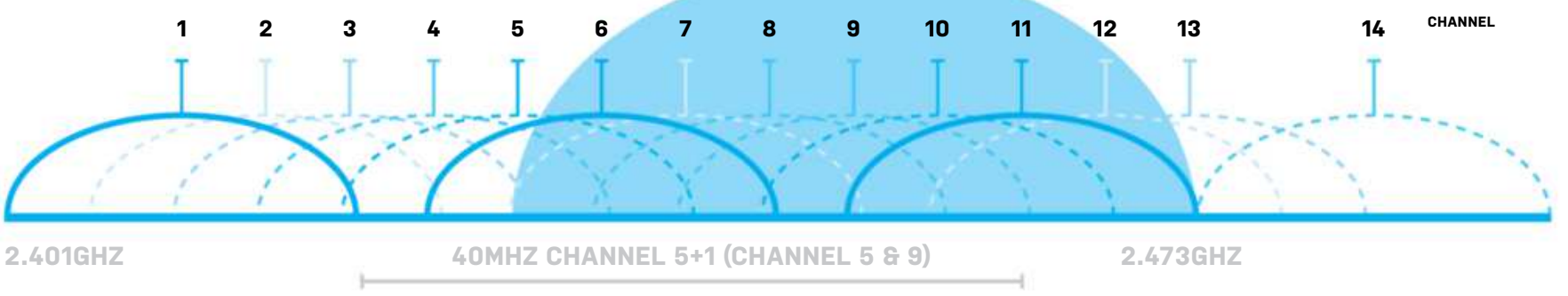


2.4GHZ CHANNEL ALLOCATION

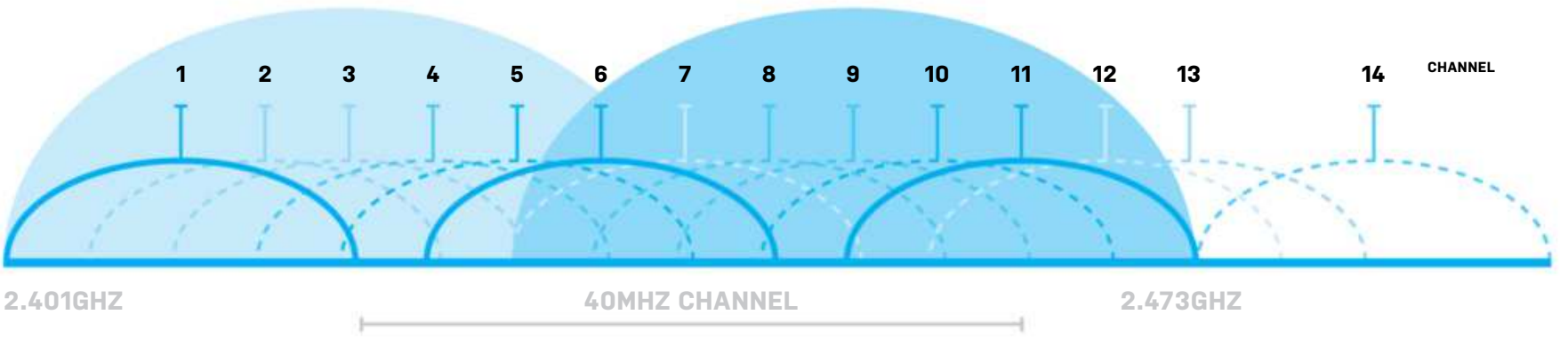
This diagram shows all the channels, plus the main free ones at 1, 6, & 11.



The US 2.4GHz free spectrum only has room for one 40MHz channel.



This diagram shows how the 40MHz channels overlap.



At 2.4GHz, the 5MHz channels overlap, offering just three 20MHz channels and one at 40MHz in the US.

(ACK) and ready to send/clear to send (RTS/CTS) signals, with fixed data packets, and mandated waits. The end result of which means data can be sent and received in noisy environments, with unconnected devices trying to send on the same wavelength and the same channel. Devices can still connect, emails are still sent and received, and nobody dies, which is good.

We're now at a point where we can ask: How is the data actually imprinted on the radio signal? It takes the form of a type of modulation—a system where the waveform is altered in a way so that the data can be retrieved at the receiving end.

There have been various types of modulation used before consolidating on the industry QAM; the various options all balance speed against robustness in noisy environments. Going back to ancient

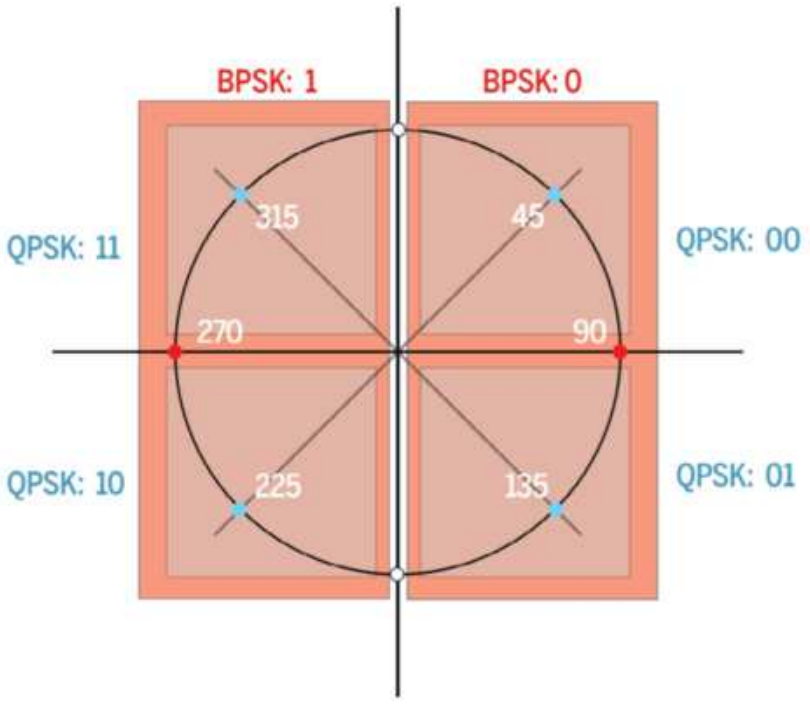
BANDY GOODNESS

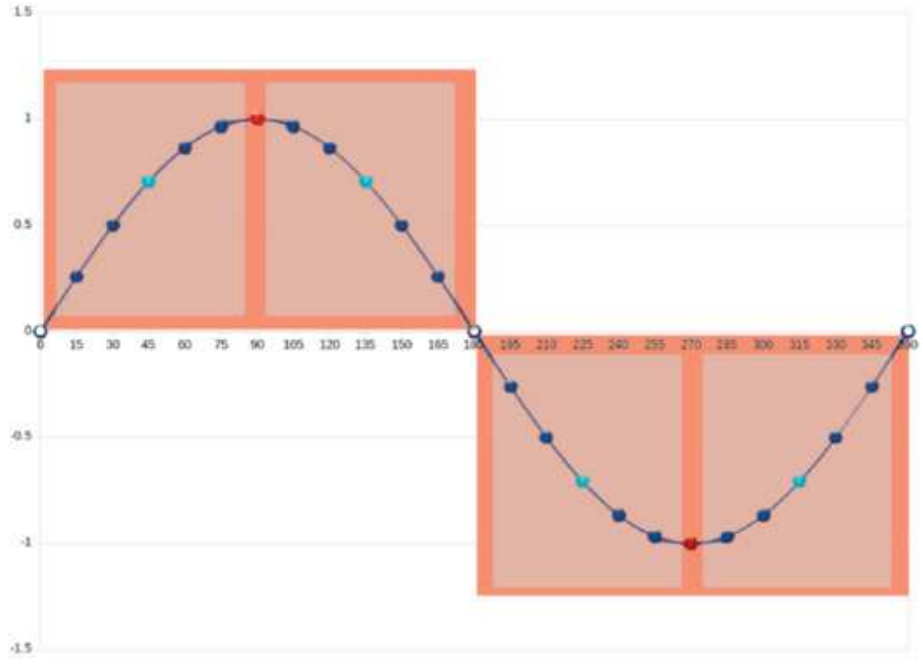
We're talking about wavelengths here as an aside, because the topic can distract from the core issue of how wireless data is transmitted. The wavelengths used for public wireless have been standardized to the 2.4GHz and 5GHz bands; think of these as the "cables" used to transmit the data.

The 2.4GHz wavelength has been key, because it's an all-important wavelength that, in most of the world, is an open unlicensed frequency. Why is that important? The 802.11a standard was adopted in the United States, and was based on a 5GHz wavelength. Able to transmit twice the amount of data as 2.4GHz, there were strong moves to have 5GHz the de facto wavelength at the end of 1999.

The problem at the time was that outside of the States and Japan, the 5GHz range usually required a license; in some regions, it was restricted for military use. Both factors delayed release and greatly increased the cost. This changed in 2003, when the frequency was freed up in Europe, due to the increasing demands being put on the 2.4GHz range, but by then, it was too late for 802.11a, because far cheaper and easier-to-implement 802.11b and g gear had swamped the market. Another troublesome aspect is that the 5GHz frequency is more readily absorbed by walls, cutting the working distance dramatically, and negating most of the speed advantages. The truth is, with radio waves, it's not their speed that matters, it's what you do with them that counts. But for 5GHz, its advantages would come back around....

Has anyone told Bob he's going to have to find another color for ax?





history, the original 802.11 and 802.11b used the very slow Barker 11-bit "chip" sequence to modulate any signal, while direct-sequence spread spectrum or DSSS was used to multiplex the signal itself, and avoid interference. This pads the original data with pseudo random "noise" data, and makes for a very robust if very slow (1 or 2Mb/s) signal.

One big advantage that the original 802.11a standard had is that it used QAM—it also made it more complex and expensive, hampered implementation, and delayed uptake, enabling 802.11b to take a lead, but it was technically superior, like Betamax—that's Quadrature Amplitude Modulation. Hurrah, we know some of those words!

Above, you can see an image of a traditionally drawn sine wave, with some numbered dots on it. Alongside this is a "polar co-ordinate" chart (a circular plot, in other words) representation of the same sine wave. This plots a full cycle of the wavelength around the 360 degrees of a circle, and you can see where the path tracks through.

Binary and quad phase keying is robust, but slow.

You can see how the combination of QAM levels, channel bonding, and streams helps increase speed; we've simplified the options here.

Let's send some data. We'll say that if you receive a waveform that's 0–180°, that's a 0, but if it's shifted to 180–360°, it's a 1. We've just invented binary phase shift keying; shift the phase 180°, and you change the value. On a polar chart, you'll see this gives a huge margin of error, making it very robust, and it's the base modulation scheme for 802.11a/g/n/ac.

The obvious next step is to say why not encode a number for every 90 degrees of a phase shift? This is quadrature phase shift keying, and it enables you to encode two bits and twice the amount of data in the same amount of wavelength, but you half the margin of error.

This is where QAM steps in. As you might have guessed, it modulates not just the phase, but also the amplitude of the wave. If you now have four bits of data per quarter, this enables us to encode four bits per wavelength frame, but with the margin of error now a quarter of the size. This is called 16-QAM, and if you think this is impressive, 802.11a supported 64-QAM back in 1999, and 802.11ac supports 256-QAM. But at this level, the margin of error becomes even smaller. QAM is a sliding system— as noise in the signal increases, the router falls back from 256-QAM to 64-QAM, then 16-QAM, 4-QAM (QPSK), and eventually BPSK, reducing the data rate, but increasing the reliability as that happens.

802.11AC WIRELESS SPEEDS

SPATIAL STREAMS	MODULATION TYPE	CODING RATE	DATA RATE IN MBIT/S 8 B CHANNELS			
			20MHz	40MHz	80MHz	160MHz
1	BPSK	1/2	7.2	15	32.5	65
1	QPSK	3/4	21.7	45	97.5	195
1	16-QAM	3/4	43.3	90	195	390
1	64-QAM	5/6	72.2	150	325	650
1	256-QAM	5/6	N/A	200	433.3	866.7
2	BPSK	1/2	14.4	30	65	130
2	QPSK	3/4	43.3	90	195	390
2	16-QAM	3/4	86.7	180	390	780
2	64-QAM	5/6	144.4	300	650	1,300
2	256-QAM	5/6	N/A	400	866.7	1,733.4
3	BPSK	1/2	21.7	45	97.5	195
3	QPSK	3/4	65	135	292.5	585
3	16-QAM	3/4	130	270	585	1,170
3	64-QAM	5/6	216.7	450	975	1,950
3	256-QAM	5/6	288.9	600	1,300	2,600
4	BPSK	1/2	28.8	60	130	260
4	QPSK	3/4	86.8	180	390	780
4	16-QAM	3/4	173.2	360	780	1,560
4	64-QAM	5/6	288.8	600	1,300	2,600
4	256-QAM	5/6	N/A	800	1,733.2	3,466.8

IN BONDAGE

Earlier, we mentioned channels, which are bandwidth frequencies within the 2.4GHz or 5GHz

wavelengths. Back in the days of 802.11g, a number of non-standard products appeared—an annoying trend that broke compatibility—such as rangeMAX and SUPER-G, which offered enhanced speeds, but were incompatible with other "g" products. Some of these products used channel bonding, a transmission technique officially used in 802.11n to double data rates by using the spectrum of two channels going from 20MHz to 40MHz per channel, literally double the speed of transmission.

The problem—especially with the non-standard gear—is that in the 2.4GHz band, the number of available channels is limited to just three; outside of a residential setting, it's almost certain that interference is going to be encountered, especially when you take into account Bluetooth, cordless DECT phones, and microwave interference, also in the 2.4GHz range.

When 802.11ac was introduced, additional channel bonding options were added of 80MHz and 160MHz, but only for the 5GHz wavelength. To be clear, the 802.11ac standard only works on the 5GHz bandwidth, and 2.4GHz capabilities are provided through the 802.11n specification.

HOW ABOUT SECURITY?

It's staggering to think that security for data transmitted wirelessly almost seems as though it was an afterthought. The original Wired Equivalent Privacy (WEP) doesn't even mention encryption or protection, but was devised at a time when US export restrictions limited encryption to 48 bits, and so, as an international standard, WEP started life hamstrung. Sure enough, in 2001, it was demonstrated that WEP could be cracked in minutes via packet sniffing, because the encryption system was fundamentally flawed.

As a matter of some urgency, a replacement system was devised: Wi-Fi Protected Access, or WPA. This arrived in 2003, and was a requirement on all ratified 802.11g equipment—802.11a hardware ended up with support, too. An important improvement was that WPA uses 48-bit RC4 encryption when sending the shared key, rather than the 24 bits of WEP, and the key changes for every frame, making it unlikely that it could be cracked in time.

WPA was a stop-gap measure, such were the failings of WEP. The full 802.11i security implementation is called WPA2, and was rolled out in the middle of 2005. This replaces the old RC4 used with WEP and WPA with a far securer encryption—from 128 to 256 bits. It also implements a new packet encryption that is far enhanced over the insecure WEP system and the improved WPA implementation, and is the required system on 802.11n onward. At the start of 2018, WPA3 was announced, and will be required on the next generation of wireless devices. It's specifically designed to repel brute-force attacks, and improve device connections without screens. Hopefully, you'll see WPA3-capable devices and routers from the end of 2018.

Keep your eyes peeled for WPA3-certified devices.

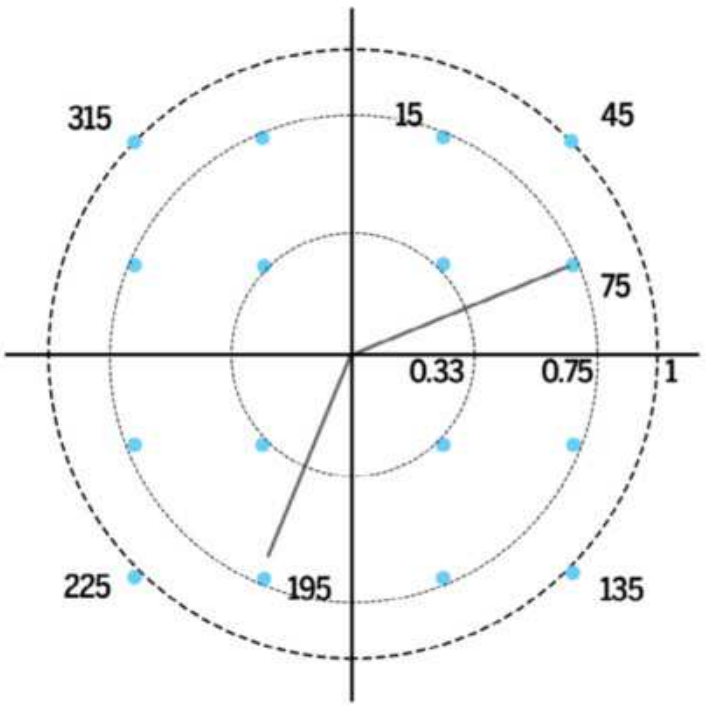
BEAMING

So, we've improved the speed of wavelength, used faster channels, and packed more data into each cycle—what's next? Sending more streams at the same time. The introduction of MIMO technology—Multiple Input Multiple Output, which is a fancy way of saying lots of antennas—was another case of the industry jumping the gun. Pre-N gear arrived packing MIMO, but it was never going to be fully compatible with final ratified N gear—though Draft 2.0 gear was.

MIMO isn't a particularly difficult idea to get your head around—simply put, instead of sending a single stream of data, you bolt on another antenna and send two streams, or up to four with 802.11n. The 802.11ac standard bumped the maximum to eight. Be aware that not all antenna can be used. Typically, the format "TX x RX = Max" is used to indicate "transmit antenna x receive antenna = maximum actual streams."

A technology that was introduced in 802.11n, but has been better deployed in 802.11ac, is something called beamforming. This is a signal processing trick, which uses destructive and constructive interference to deliver optimized areas of signal just where your device happens to be. It's basically tuning the waveforms to enhance, rather than cancel out, each other.

With 802.11n, this system didn't work as well with different manufacturers, largely because it had to fall back on "implicit mode," where it has to assume the transmit and receive power is the same, with no feedback. While this can work, it's rarely the case that the transmit path is symmetrical.



Modulating the phase and amplitude suddenly opens up big increases in throughput.

Far better and now improved with 802.11ac is "explicit mode," where feedback can be sent in the form of complex vector tables, which contain information on the power of each subcarrier. This can increase the signal by 2–3dB, basically doubling the signal strength, making the difference between being able to support 16-QAM or 256-QAM. Because it's possible to feed back as quickly as 10 to 25ms, this even works with moving devices.

Another thing to keep in mind, and another reason this system wasn't optimized for 802.11n, is that it requires four antennas to offer both MIMO and beamforming to a single user. Beamforming is transmitting the same signal over two antennas to optimize signal strength, but it then requires two additional antennas to deliver MIMO capabilities, too. With 802.11ac being able to offer eight antennas, it's capable of supporting four users with beamforming simultaneously, now called MultiUser MIMO, or MU-MIMO.

Some recent routers claim "tri-band" capabilities with two separate 5GHz bands. This non-standard 802.11 addition neatly enhances

routers to better support MU-MIMO, because they can simultaneously serve one device on the lower 5GHz channels and another device on the upper 5GHz channels.

THE AX MAN

That drops us neatly off at the future. The next iteration of Wi-Fi is upon us: 802.11ax has yet to be ratified, but Qualcomm has already released a number of 802.11ax-supporting chipsets based on draft standards. There were also various unreleased products being demonstrated at CES 2018, such as the D-Link DIR-X9000, a 4x4 MU-MIMO device due late in 2018, but the standard isn't slated to be ratified until early 2019. So, should you care?

While 802.11ac squeezed more from the 5GHz band with MU-MIMO and greater channel bonding, 802.11ax is all about refinement, using the 5GHz bandwidth in smarter ways. While this is going to lead to faster connections, it's largely aimed at supporting multiple users far more efficiently.

A key change is a switch from OFDM, a widely used type of multiplexing—used in Wi-Fi since 802.11a and g onward—to an even more efficient form, called OFDMA. We'll avoid the complexities of this multiplexing—it's the sort of thing that would take multiple classes at university to explain—but it closely overlays subcarriers orthogonally for efficient use of the wavelength, and key to OFDMA is that individual subcarriers can be assigned to individual devices. With OFDM, that is simply not possible. Plus, it frees up routers to switch to the best channels for specific devices. All of this cleverness, however, means OFDMA is much more costly to implement.

QAM has been increased to 1,024. This, alongside the shift to OFDMA, should increase available throughput fourfold. It's also going to enable the MU-MIMO to work both in the downlink direction (from the router, as with 802.11ac) and also on the uplink side. Other subtle improvements are a doubling in the available guard interval—to avoid Doppler effects—for improved outdoor performance, plus a double and quad-length symbol duration for further efficiency.

It looks like the initial 802.11ax consumer routers will be pushing four antennas initially—so they can sell eight-antenna units the following year, we guess. Ignore the hyped 11,000Mb/s claims you'll see; that's using the old trick of combining the 2.4GHz and 5GHz bands together (some even do this with the 60GHz same-room network band). The truth is, until you have devices in your home that use 802.11ax, there's no point rushing out and buying routers. History has shown that it pays to be patient with wireless technologies, but once settled, 802.11ax promises sounder, faster home networks.

Multiple-antenna MIMO gives two, four, or more streams.

WHAT A MESH!

Linksys Velop is one of the fastest mesh options but it doesn't use 802.11s.

Wireless mesh networks are a real thing, not some sort of marketing hype for once, so what are they? As with many technologies, mesh networks span out of military development to increase the overall range and robustness of a wireless network by linking and routing through individual wireless devices.

For us home consumers, the appeal is to have a home network that offers a reliable, fast, and consistent network. The number of wireless devices in a smart home is getting cray cray, as the kids would say, and a mesh network made of two more routers can offer smarter use of the available wavelengths and bandwidth through a variety of tricks. It can maximize bandwidth by utilizing the channels and wavelength with the least interference. There is a standard for this, defined by 802.11s; some devices, such as Google Wi-Fi, use this, but companies are free to ignore it and implement their own mesh protocols to improve performance.

We took the Linksys Velop system for a spin. We first set up one unit and tested the throughput in two control locations: in the same room, and a room away, blocked by a brick wall. We then set up a second unit and tested to see the effect on overall performance in the same locations.

The same-room control connected at 300Mb/s, with 12.8MB/s upstream and 20.8MB/s down transfers; the one-room-away control connected at 121Mb/s, with 3.4MB/s up and 8.5MB/s down. With the second Velop in action, the same-room performance was 13.9MB/s up and 20.5MB/s down; one-room-away connected at 300Mb/s, and tested 9.9MB/s up and 21.6MB/s down. So, a marked increase in the previously poorly serviced area.

STOP THIS MADNESS!

Brace yourself: A new Wi-Fi standard is coming....

We've talked about the 2.4GHz and 5GHz wavelengths extensively, which should be enough for anyone, but there is a third: 60GHz. If you've never heard of Wireless Gigabit, or WiGig, we don't blame you. It sprang up about a decade ago, aiming to utilize the unlicensed 60GHz wavelength, and develop a wireless gigabit standard. We thought nothing came of it; there were talks and demonstrations of wireless HDMI and USB, but nothing that seemed to catch on.

The attraction of 60GHz is that it's freaking fast. The 802.11ad 60GHz standard delivers 4.6Gb/s on one channel, and potentially four channels can be bonded together. The downside: 60GHz can't penetrate physical barriers, so we're talking same-room or even same-desk networking. It could be awesome for VR 4K wireless headsets, but you'll have to figure out how to get that networked.

It's likely this is what stopped 60GHz products being widely rolled out. Solutions have been around since 2014, and the odd Wi-Fi router appeared in 2016, but the additional confusion and complexities have seemingly put off manufacturers. Perhaps we'll finally start seeing wider use of 60GHz in 2019....

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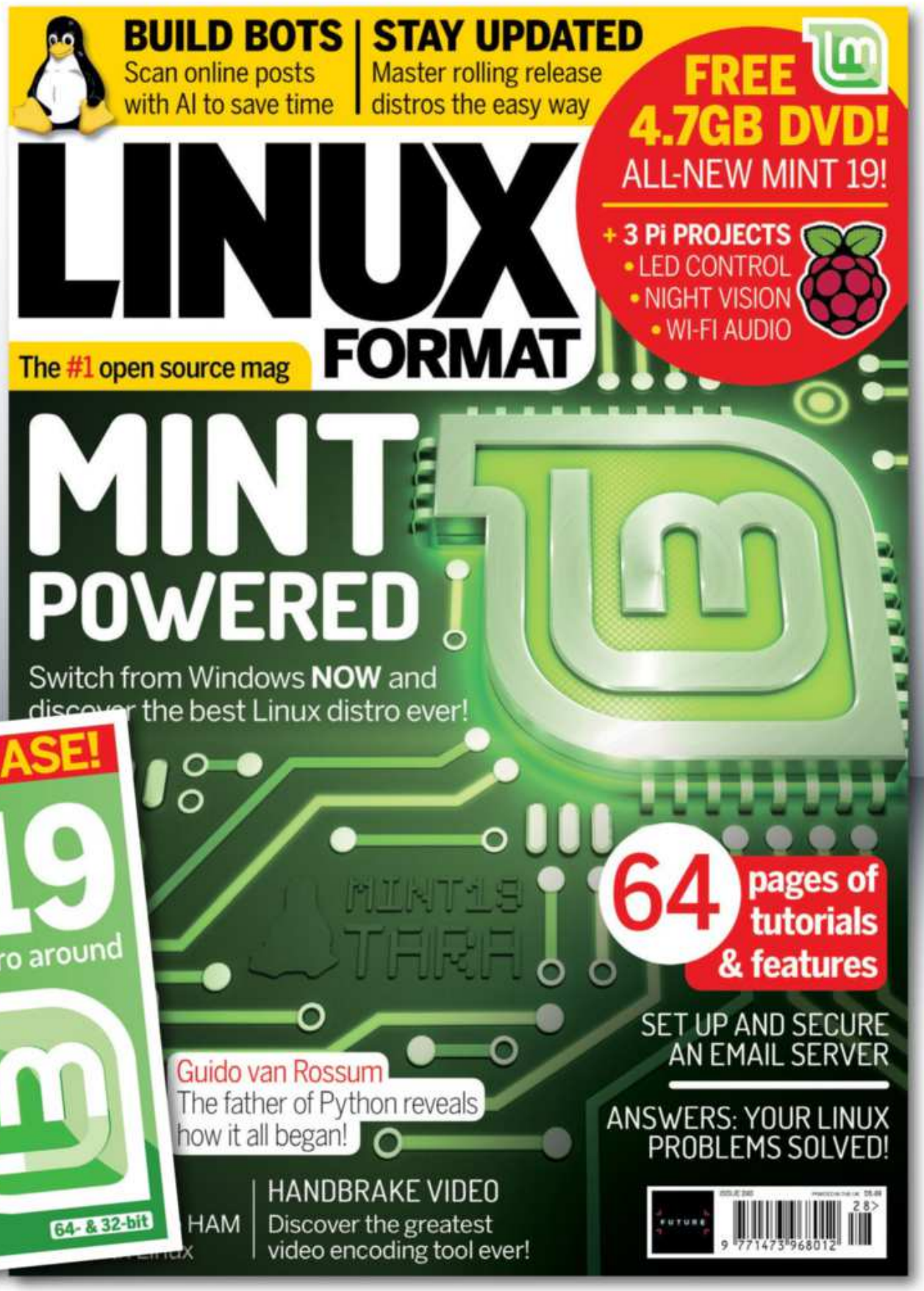
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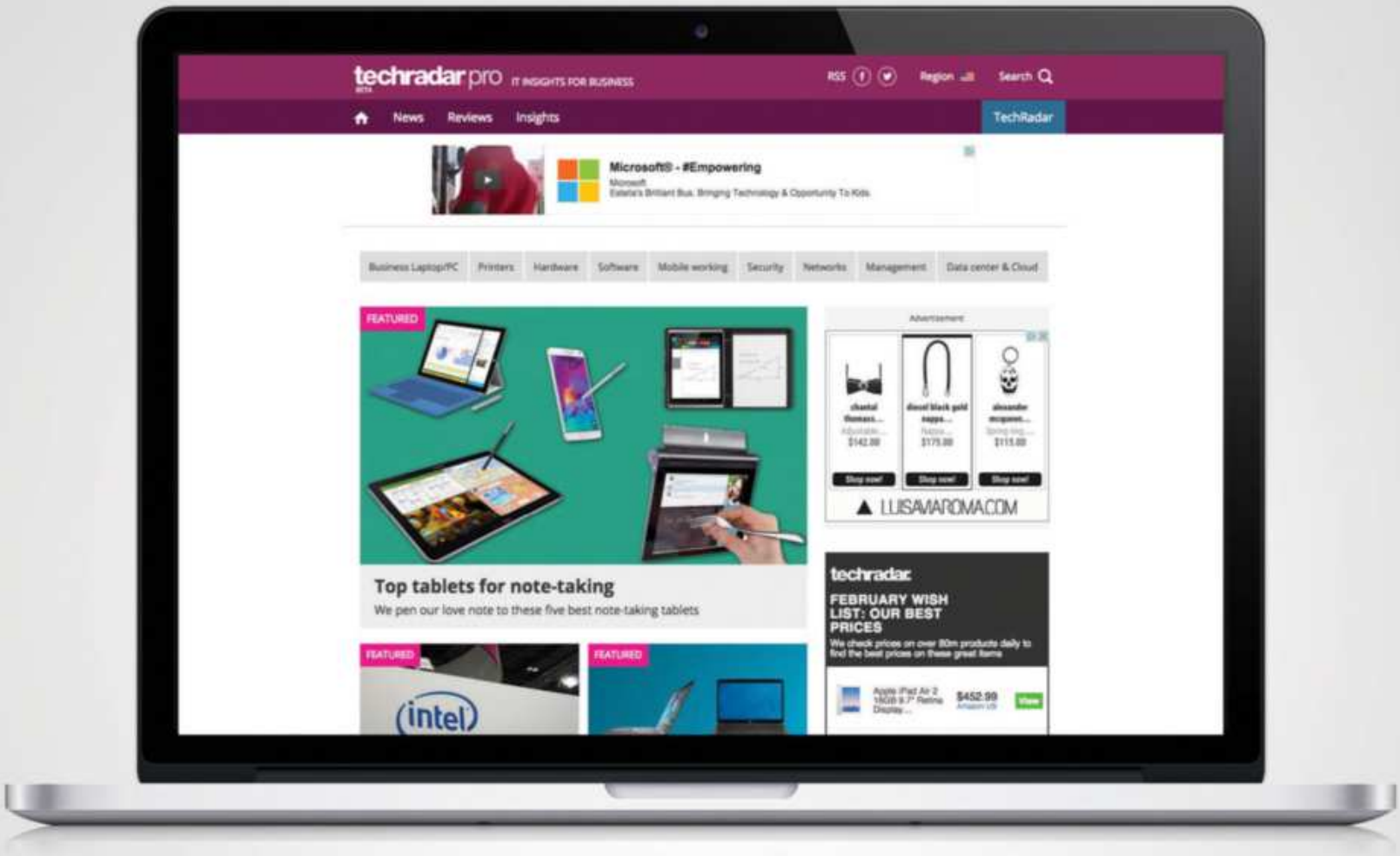

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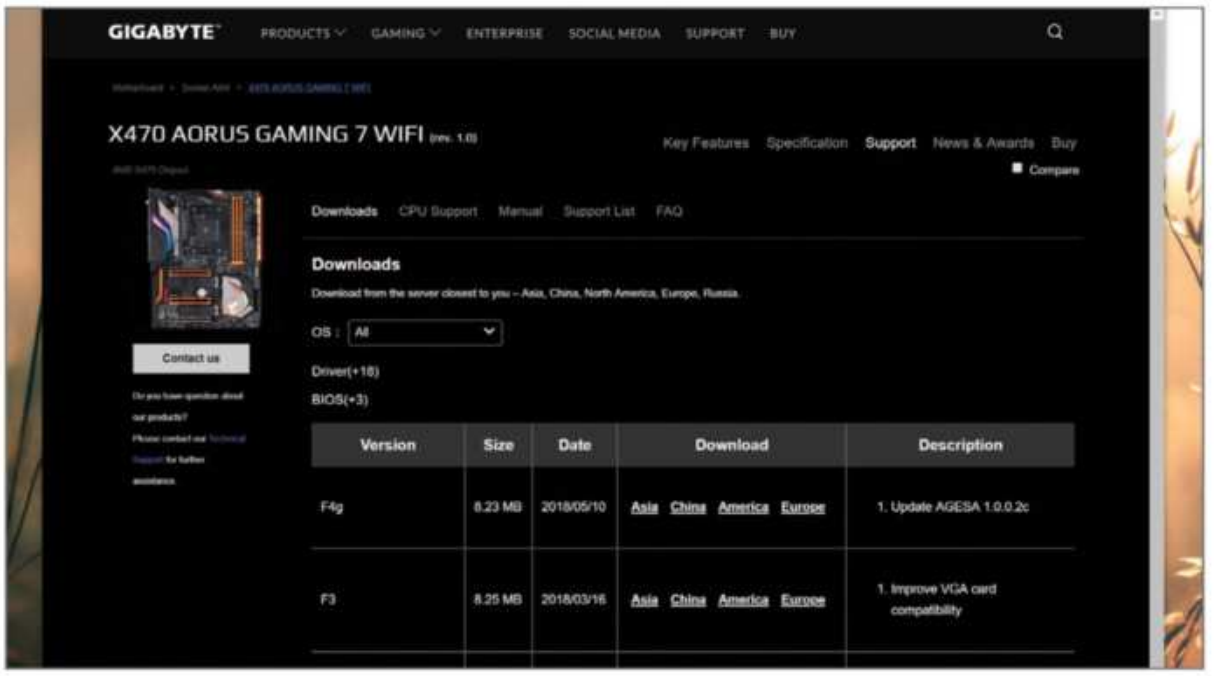

UPDATE YOUR MOTHERBOARD SOFTWARE

When it comes to having a healthy, secure, and speedy rig, getting the latest updates is vital. To do this, we recommend checking your motherboard model's web page every two to three months for any new software, chipsets, or BIOS updates you can find. It's a small detail, and sometimes a frustrating one (especially updating the BIOS), but it can provide you with more stability and even a quieter system. $Free

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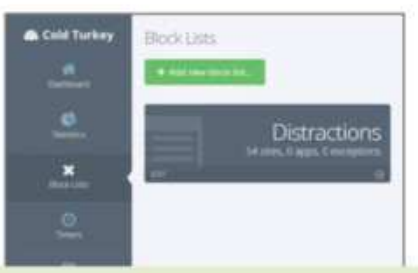

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Use Cold Turkey Blocker to eliminate digital distractions

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Tame your web browser tabs with the Toby extension

ZAK STOREY
DEPUTY EDITOR

FALLING OUT OF LOVE

I'll just come out and say it: I've fallen out of love with *World of Warcraft*. It was bound to happen at some point. Things change, expansions shake things up, and it's just lost its appeal. It's now slower than ever; I'm sure that's fine for some folk, but the complexity and fluidity of the gameplay was what kept me coming back.

The reason it's such a big deal for me is that without that game, it's unlikely I'd be here. From graphic design skills I developed while working on custom UIs that saved my degree, to leadership abilities generated through raid leading, to touch typing, system tweaking, and overclocking to get a higher frame rate, it's been a pivotal part of my technological journey.

It's also been a massive time sink. I dread to think how many hours I've spent on it. And although I still play games, the amount of time I spend on them is fractional in comparison. So, what have I been doing with all this extra time? Learning another language. Norwegian, in fact, or Bokmål to be more precise, using a nifty little website called Duolingo. Instead of spending hours playing games, I'm trying to do something more productive, and as I'm part Norwegian, I figured it'd be a good crack to learn the language. It's a completely different experience, yet the way Duolingo's set up makes it feel like a game, and as a completionist, it's absolutely appealing to me.

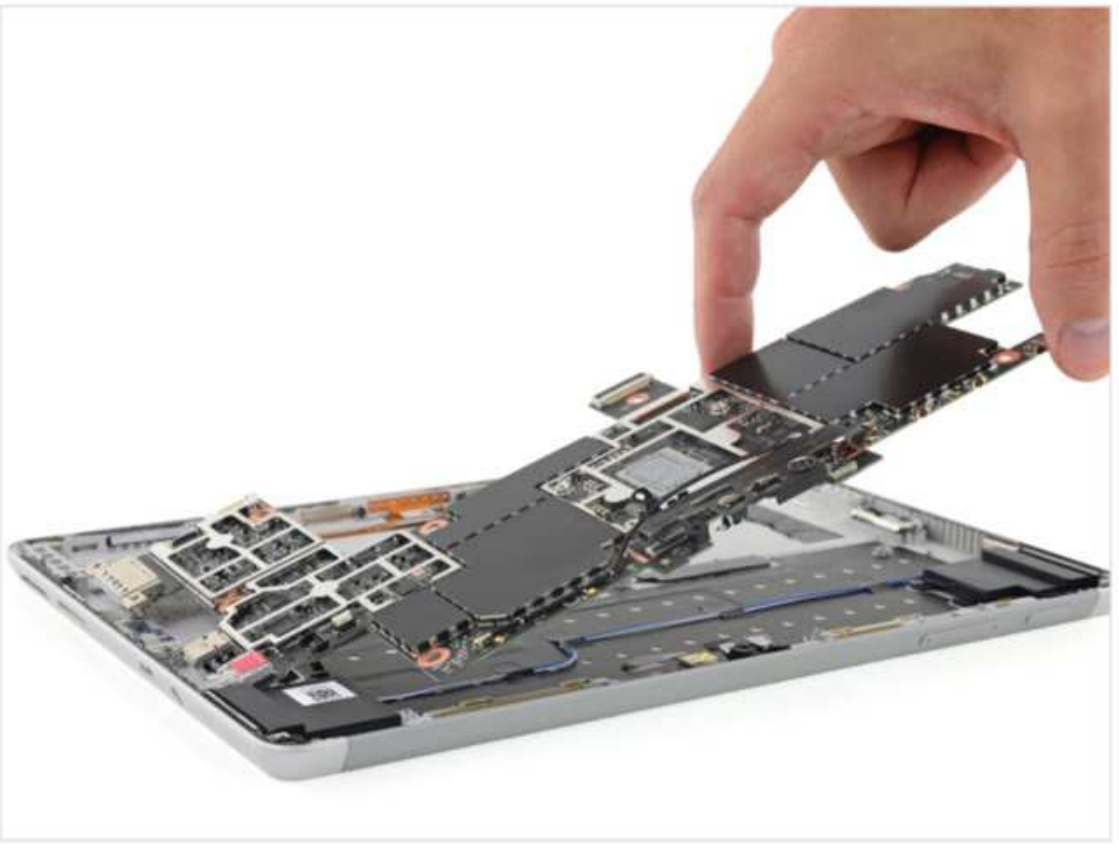
↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

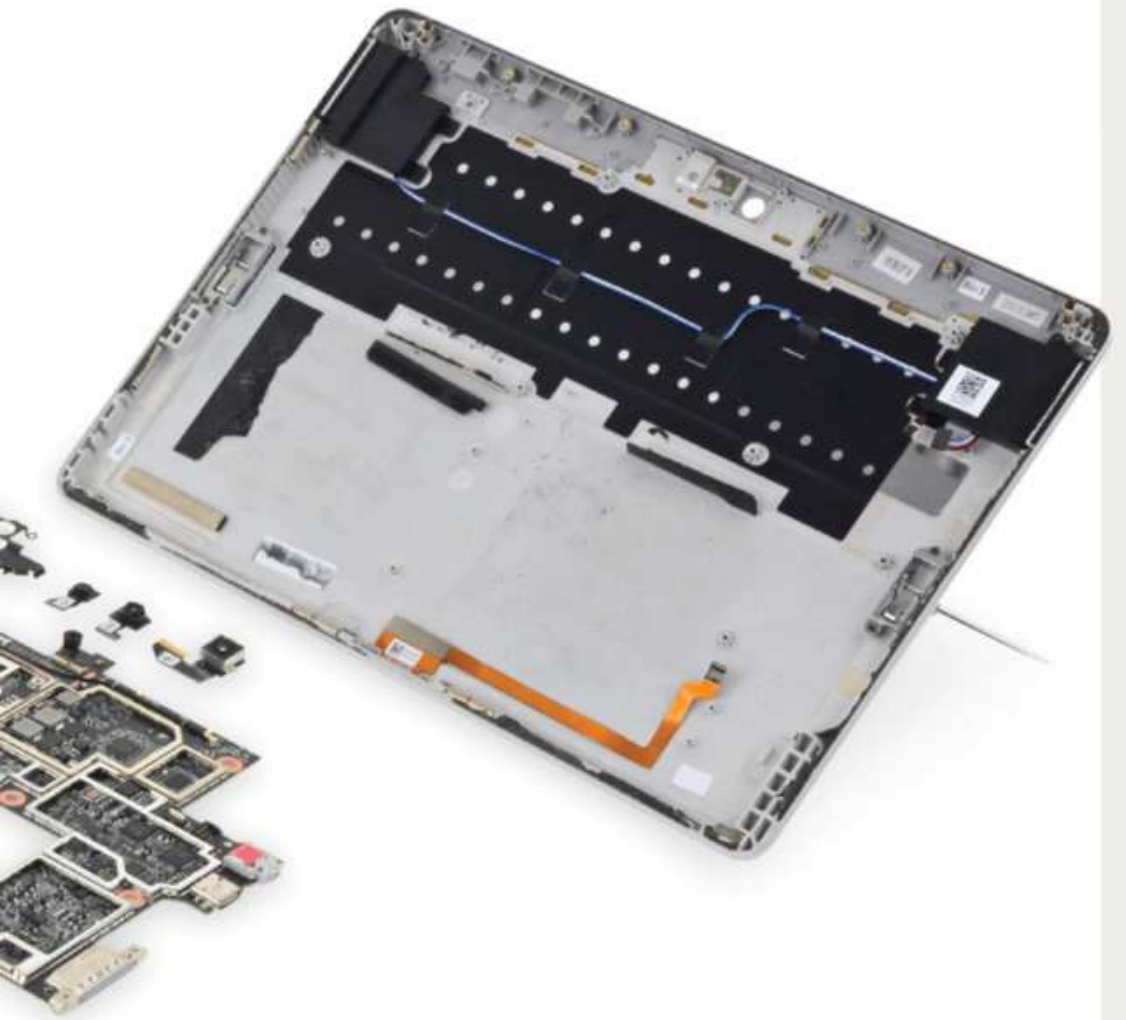
Microsoft Surface Go



There isn't any nasty glue holding the motherboard in place, but there are plenty of tiny screws and tape.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
To learn more, visit www.ifixit.com.



We've seen this goopy glue on previous Surface tablets, but it isn't quite as terrifying with the Surface Go.

BACKGROUND

Microsoft just revealed a 2-in-1 for those on the move—those wanting a Surface with a little less pro, and a little more go. This Surface might have a lot going for it, but there's only one thing we care about: Can you service it on the go, or will it be stopped in its tracks by tired batteries and shattered screens? Only one way to find out—ready, set, teardown!

MAJOR TECH SPECS

- 10-inch IPS 1800x1200 (217 ppi) multi-touch display
- Dual-core 1.6GHz Intel Pentium Gold 4415Y processor with integrated Intel HD Graphics 615
- 4GB RAM (8GB optional)
- 64GB eMMC storage (128GB NVMe SSD optional), additional storage via microSDXC
- 8MP primary camera with 1080p video; 1080p selfie camera
- Windows 10 in S mode

KEY FINDINGS

- Compared to the Pro, the Go looks to have smoother curves, rounder edges, and a vaguely more iPad-y aesthetic. The Surface Go doesn't follow the fewer ports trend: This tablet packs a USB-C port, headphone jack, a couple proprietary connectors, and an SD card reader.
- If we've learned one thing after five years of Surfacing, it's how to open these things: Our well-used iOpener brings the heat, then a suction handle and opening picks attack the ample adhesive. Once the display's off, we're pleased to see that Microsoft allowed it a fairly long leash, making it easier to disconnect the display without damaging the cable.
- To our great surprise, the Surface Go has an immediately disconnectable battery. With no need to fully remove the motherboard, repairability is looking up. Or is it? Removing the battery is just like the bad old days—two giant pads of adhesive put up a staunch fight. The battery in the Go is a lot smaller, at 26.12Wh, than any of its pro-level predecessors—even the similarly sized iPad 6 packs a 32.9Wh unit.
- Turning our attention to the Wi-Fi antennas, we expect to find them mangled after the hack-and-slash display separation. Having the display glass glued over the top of Wi-Fi antennas has wreaked havoc on many a Surface Pro repair attempt. These antennas are miraculously unscathed, though.
- Our journey beneath the Surface doesn't get any easier as we move on to the motherboard. There's no glue here, but we're forced to excavate through seemingly endless layers of tape, shields, and hidden screws in order to unearth the board.
- All that silicon, yet this Go is fan-less and heatpipe-less. A thin copper shield and some thermal paste have to do the heatsinking for this would-be PC. It's certainly a radical departure from the thick copper tentacles we found on the fifth-gen Pro. Hopefully, it's enough for the Go's power-sipping, non-Turbo'd processor.
- Repairability score: 1 out of 10 (10 is easiest to repair). The smaller form factor seems to make the glass easier to remove without breaking, but it's still terrifyingly hard. If this is expected to replace a PC, the lack of upgradability will severely limit its lifespan. The lack of modularity, especially on high-wear ports, makes repairs expensive. Adhesive holds many components in place, including the display and battery. Replacement of any part requires removal of the display assembly, an easy (and expensive) part to damage.

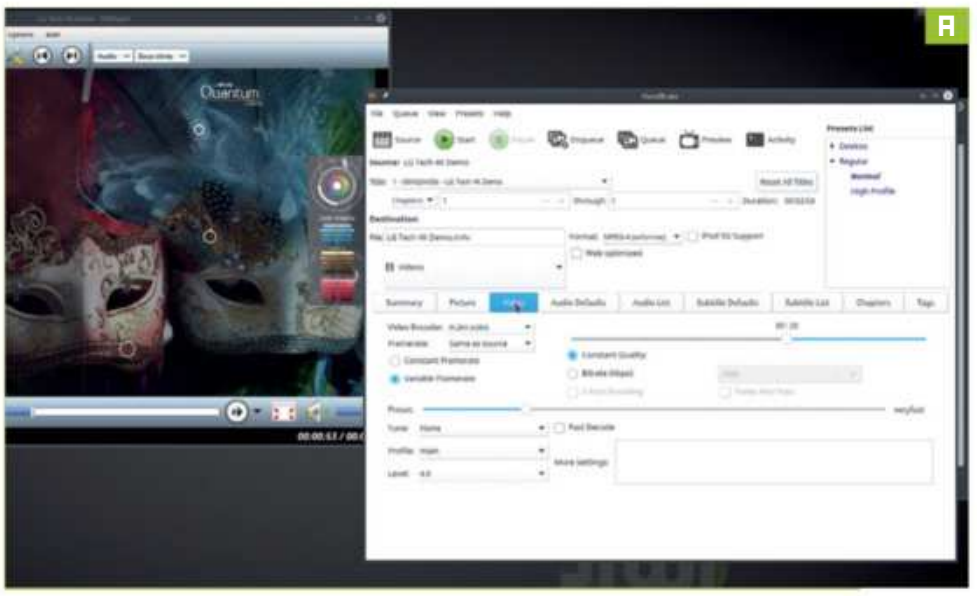
Encode Video Faster and Better

YOU'LL NEED THIS

HANDBRAKE
Download the open-source video transcoder from http://handbrake.fr.

ACCORDING TO ITS WEBSITE, "HandBrake is a tool for converting video from nearly any format to a selection of modern, widely supported codecs." Although it's certainly worth exploring, we should state that HandBrake is not easy to understand if you're a novice—the program is clearly designed with the power user in mind. Nevertheless, with some tutorial scenarios, we can hopefully break it down into something more easily digestible, and make the interface less intimidating.

HandBrake's interface is slightly unconventional and can be confusing at first, but stick with it, as some parts function beautifully and really make HandBrake stand out from the pack. We don't have space to cover the entire program, but hopefully we can take you through enough of the interface for you to be able to start encoding your own videos comfortably and confidently. –JOHN KNIGHT



1 INTO THE GUI

To break things down into something more easily digestible, we'll run through some simple scenarios to get a feel for the GUI. We'll start with single-file scenarios of low complexity, then move on to multiple files in a queue, after which we'll add more advanced options to achieve some genuinely high-quality rips. Let's start by turning something big into something little.

›› H.265 is set to become the new standard in online video, with its drastically reduced file size over its H.264 predecessor. Therefore, it seems fitting to shrink an H.264 video down into a much smaller H.265 video. So please get a big H.264 file ready (these are usually called .mkv), and we'll make it mini.

›› If your computer is sufficiently beefy to handle H.265, please follow along, otherwise try substituting these codecs with your own example of an older source being compressed with a newer codec.

›› To encode a single file, the process is pretty easy:

- **Click the "Source" button, and choose your file or disc.**
- **Choose your formatting and codec output options.**
- **Click "Start."**

›› The GUI, codecs, and file formatting may take some explaining. Start by clicking the big "Source" button at the top-left, and pick your large H.264 source file. Next, choose the destination for the encoded video. By default, HandBrake outputs any files into the Videos folder of your home directory. If you would prefer another output folder, you can change that by accessing the drop-down box under the "Destination" heading.

›› You now have to choose your format, which is also under the "Destination" heading. There's a choice of MPEG-4 or Matroska: If your video is for something like social media, choose MPEG-4, but if your video is a full-length movie, choose Matroska. Different software and different audiences expect one format or the other, so choose the one that's most suitable for the task.

›› To choose the video codec, click the "Video" tab below. From the "Video Encoder" menu, choose the H.265 codec. If H.265 isn't available in this menu, the codec may not be installed on your system, in which case, you need to find it online, and install it.

›› From here, we won't change any other options—we'll just leave the defaults alone and examine the output. To get the ripping started, just click that big green "Start" button. Your estimated time appears below—brace yourself, as this may take a while. After the rip is completed, check out the resulting file that's been saved into your Videos folder.

›› Using the default settings, we shrunk a 16.6GB H.264 video into a 2.3GB video with excellent image quality. But before you get too excited, there was still some inevitable picture degradation, and that audio is down-mixed from DTS surround into stereo. Those are still pleasing results for casual viewing, but we'll re-explore these issues later.

›› We've shrunk something down for a better file size, but what about reversing the process? That might sound crazy, but H.265 is very processor-intensive and may be simply too much for older machines to play properly. Though relatively beefy, this machine is a few years old now, and when we tried to play an LG 4K tech demo in H.265, it almost brought the machine to a halt.

›› By using an older codec, you can guarantee more compatibility with older machines. So, what if we converted the 4K video into H.264—would it play?

›› Following the same steps as before, we chose LG's tech demo as our source, and Matroska as the format, but this time under the "Video" tab we used H.264—the system default. And how did it run? Perfectly [**Image A**].

›› H.265 may not have worked properly in 4K, but 4K is already a big ask of any system. What about H.265 in a resolution that's more realistic, such as 1080p?

›› With the 4K demo loaded, we went back to the "Video" tab, and changed "Video Encoder" to H.265, but to change resolution, you must open the "Picture" tab. The controls under "Storage Geometry" adjust width and height.

›› When you hear someone speak about 1080p, 720p, or 480p, they're referring to the height. So, to scale up or

down, just adjust the height control, and the width adjusts with it. For reference's sake, in 16:9 format, 1080p is 1920x1080, 720p is 1280x720, and 480p is 854x480.

» How did the machine perform in 1080p instead of 4K? It was great [Image B]. Which begs the question: Do consumers really need 4K? Or is it a marketing wheeze rustled up by TV manufacturers?

2 MANY FILES, LIGHT WORK

Now, this is where HandBrake really comes into its own. The Queue feature enables you to complete a list of jobs instead of just one, which is perfect for running a bunch of encoding jobs while you're away from the computer—especially overnight.

» Once you get used to which button does what, the process for multiple files is pretty easy:

- **Click the "Source" button, and choose file or disc.**
- **Choose your formatting/output options.**
- **Click "Enqueue," which puts an encoding job in the list.**
- **Repeat with another file, and "Enqueue."**
- **Press "Queue" to browse your existing jobs; click the "Edit" button (the icon with the pencil) if you want to make any changes.**
- **Click "Start."**

» If you find that all your settings have disappeared, and you want to make changes, the GUI is still in Queue mode—just hit the button again. We particularly like that each "Queued" video has its own settings, and changes made to one video don't apply to another.

» If you need to cancel something for any reason, we like the four options you get when you hit the big red "Stop" button: "Cancel Current and Stop"; "Cancel Current, Start Next"; "Finish Current, then Stop"; and "Continue Encoding." It might be a small touch, but it's a thoughtful one that might save you hours of lost work.

3 TWEAKING FOR QUALITY

This is what sorts new users from the veterans—where you really get down to the nitty-gritty of video encoding. While our previous rips have all been substantially smaller than their source, they're all still relatively large, being at least several gigabytes each. What if you want to make the rips smaller still?

» The first place to try is bitrate. Open the "Video" tab, and you'll see a slider, a checkbox for "Constant Quality," and another for "Bitrate (kbps)." The "Constant Quality" option uses the slider: The further the slider is to the left, the higher the quality and file size; and the further to the right it is, the smaller the file, but the lower the quality. That's the easy way to do it. If you prefer more control, use the "Bitrate (kbps)" option. The default is set to 2,500, but we thought we'd try our luck squeezing it down to 1,000kb/s. With a combination of the lower bitrate, a lowered resolution of 720p, and stereo sound, we managed a file that had shrunk from 16.6GB to just over 1GB.

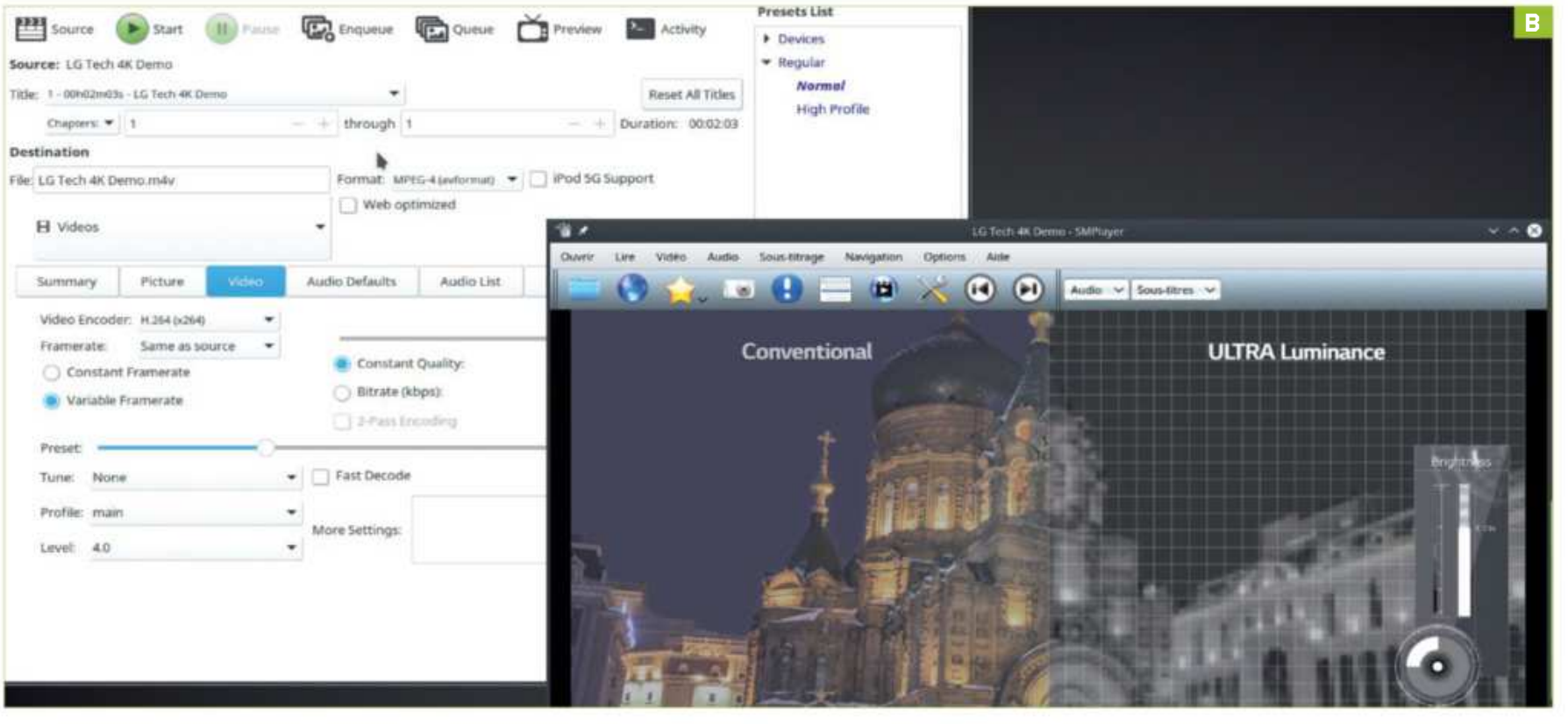
» Obviously, it was nowhere near the quality of the original, and image degradation from the compression was starting to show, but for a casual viewer, the quality would have been acceptable. Things needn't stop there,

CODECS IN A NUTSHELL

Video codecs are the formats that compress raw video into something smaller and easier to handle. Although many kinds have existed, it all really started with MPEG (Moving Picture Experts Group) back in 1988. Advances in processing power meant video compression algorithms became more sophisticated, so you could squeeze more video quality into a smaller file size. DVD's MPEG-2 was a big step up over MPEG-1, and video file sharing really kicked off in the early 2000s when DiVX/MPEG-4 was able to squeeze near-DVD quality video on to a single CD.

However, each major step in video compression requires hardware to advance with it. MPEG-4 required a decently beefy PC back in the day, but eventually hardware MPEG-4 decoding was built into basic consumer devices, such as DVD players and even car stereos. Likewise, it took some time for the hardware to catch up with the H.264 codec that's mainly in use these days, but even something as humble as a Raspberry Pi can play high-definition H.264 video without breaking into a fruity smelling sweat.

The next big thing is H.265, which needs anything from 3 to 10 times the processing power as H.264, but with the benefit of outputting at approximately half the file size. Once mainstream consumer hardware catches up with this new standard, H.265 promises to deliver genuine high-definition video streaming over even modest Internet connections.



though. As the bitrate comes down, the ugly visual artefacts really start to show up, but HandBrake has a few tricks up its sleeve.

›› While we're still in the "Video" tab, if you use the manual "Bitrate (kbps)" option, you can enable "2-Pass Encoding." This rips the video twice, but uses the data from the first rip to refine the picture accuracy in the second rip. This takes twice as long, though.

›› To refine the image, open the "Picture" tab. At the bottom is the "Filters" section. Starting with "Deblock," this cleans up that effect where lower-quality images become blocky. "Denoise" takes away noisy elements, such as film grain, that make ripping more difficult, and can reduce file size. "Detelicine" removes a combing effect resulting from the process of converting film to video.

›› Lastly, we have "Decomb" and "Deinterlace." If you've ever seen something shot on video that looks all "liney," this is interlacing. "Deinterlacing" fixes that, but it's such a common problem that there are multiple methods for deinterlacing. This means you'll have to experiment with each setting. While "Deinterlace" bluntly applies the effect to the whole video, "Decomb" attempts to detect any interlacing first, and avoid needless image degradation.

›› There is one big drawback to enabling all of these options: While a basic rip may be done in real time or less, a hardcore rip takes longer. A lot longer.

›› Test-ripping a two-hour film with all the best features enabled, it took something like 16 hours to complete. Ripping over a couple of hours is one thing, and even ripping overnight isn't too bad, but 16 hours? That adds a new level of impracticality, and you'll need to work out how committed you are to a quality rip.

4 WHAT'S AN ASPECT?

Although it's unintuitive at first, the picture controls are excellent, particularly when combined with the "Preview" window [**Image C**]. If you have a picture that needs cropping or re-proportioned to the correct aspect ratio, great. But if you have one of those irritating files that needs fixing in both areas, that's even better. Start by opening the "Picture" tab, and we'll go from there.

›› Other than removing those black borders, cropping is handy because a lot of file size can be wasted rendering black space. If you're going to do any cropping, start with that first, because annoyingly the "Cropping" controls reset the "Display Geometry" controls.

›› HandBrake has the "Auto Crop" feature enabled by default, which in most cases detects and removes black borders automatically. Interestingly, it crops out border space from any video file, not just those with differences in aspect ratio. Nevertheless, always check the "Preview" window to see that it's worked properly. Some files are so badly ripped that only a human eye can figure them out.

›› Thankfully, you can adjust the crop settings on the fly, and the "Show Crop" button is particularly useful. Flick through the preview slider to make sure everything looks right through the rest of the file before continuing.

›› You can also crop manually if you prefer. First disable "Auto Crop," which enables the "Cropping" controls, and open the "Preview" window. As you adjust the cropping dimensions, the "Preview" window updates in real time.

›› Moving on to resizing and aspect ratio, the GUI is obscure here, and takes some working out. If you look under "Storage Geometry," you'll find it all lies with the "Anamorphic" drop-down: Leave it in "Loose" if you want to resize the video, but maintain the aspect ratio; or put it in "Custom" if you want to change both.

›› With "Loose," you can adjust the width and height, but both are locked within the same numeric proportions. With "Custom," you can adjust the width and the height, and the "Preview" window grows or shrinks along with it.

›› If you want to know what aspect ratio the video is now in, uncheck "Keep Aspect" in the neighboring "Display

Geometry" field, and the "Display Aspect" readout reveals the aspect ratio. Keep resizing until it says whichever ratio you want. The geometry controls are powerful, but can be a nightmare to use.

5 LISTEN UP!

We've primarily focused on video here, but sound is half the equation, and can significantly impact the file size. Although you can do some great stuff in HandBrake, audio configuration is where the GUI lets itself down.

» For stereo output, things are generally fine. In either the "Audio Defaults" or the "Audio List" tab, you're bound to find settings that work in your codec of choice, though the "Audio List" tab is certainly easier to comprehend [**Image D**].

» However, if you want to keep the audio in surround, that takes some more work. We'll cover DTS, DTS-HD, and Dolby Surround here. Given that DTS/DTS-HD is the primary choice for surround sound on Blu-ray, we'll cover that first. Dolby Surround rules the roost on DVD, however, so we'll do that after.

» Starting with DTS and its HD cousin, we found that it's best to avoid the "Audio Defaults" tab entirely, and just open the "Audio List" tab instead. In the list below, you'll probably have a default output listing, displaying something like "English (DTS)(5.1 ch)(48kHz) → AC3 (Dolby Pro Logic II)(48kHz)."

» Click the "Edit" button with the pencil icon on the right. Now a new configuration window pops up, with essentially the same controls as in the "Audio Defaults" tab, but stripped down into something that actually makes sense.

» Choose your audio track from the "Source Track" list. Under the "Encoder" heading, choose "DTS-Passthru" (or "DTS-HD Passthru" if your file has that), at which point the other options are grayed out. Click "OK," and the audio should be properly configured with surround sound, with the listing saying it will convert from DTS to "Passthrough." There are other ways of getting it to work, but we found this was the easiest, and it avoids losing quality.

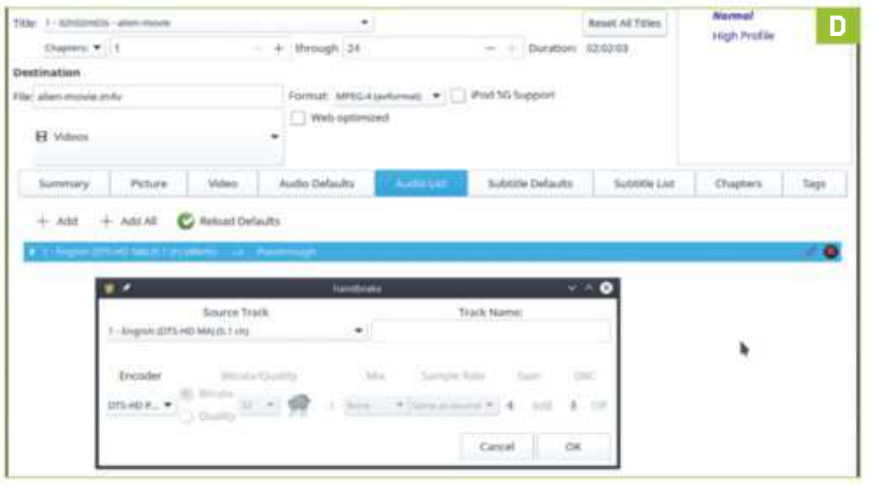
6 MIXING THINGS UP

If your amplifier doesn't support DTS, but does support Dolby Surround, we found you can remix the signal to suit. Choose "AC3" from the "Encoder" list, followed by "5.1 Channels" from the "Mix" list. This was detected as Dolby Surround on our amplifier and worked. Ironically, when we choose "Dolby Surround" from the "Mix" list, it only came out as stereo.

» With that, let's move on to keeping a Dolby Surround source. If your source audio is surround, in the list below you'll probably have a default output listing saying something like "English (AC3)(5.1 ch)(48kHz) → AAC (avcodec)(Dolby Pro Logic II)(48kHz)."

» Click the "Edit" icon as before, and again, choose your "Source Track." This time from the "Encoder" menu, choose "AC3 Passthru," at which point the other options are grayed out.

» This is the best and easiest way if you want the surround sound to stay intact. However, if you want to change options such as the bitrate or gain, you can keep the Dolby Surround by choosing "AC3" instead, with "5.1 Channels" from "Mix." And again, if you choose "Dolby Surround," you'll probably just get stereo. Resist the urge to kick a piece of furniture.



» While using passthrough for the audio is easier and results in the best quality, be aware that it substantially increases your final file size. Our example rip earlier was only 2.3GB in stereo, but with surround sound it became 6.6GB—a dramatic increase, but still 10GB smaller than its source.

» If you're serious about keeping surround in your rip while maintaining a small file size, we recommend that you experiment with codecs and bitrates until you find a solution that works for you.

7 WEIGHING THINGS UP

Ultimately, ripping is all about balance and compromise: size versus quality, compression versus compatibility, meticulousness versus practicality. What can it run on? Is it beautifully compressed, but only runs on new hardware, or are you willing to sacrifice some sophistication so anyone can play it? It's about deciding what you can live without, because there's always a trade-off somewhere.

» Furthermore, there are practical considerations to take into account. Will people be counting on you to churn out new videos quickly and regularly, or can you take your time and produce something of high quality with a small file size? And if you're planning on ripping videos regularly, should you invest in another computer that's dedicated to the task?

» These factors will all determine what kind of ripper you are, and HandBrake tends to cater to the more dedicated user. Although some of its GUI controls are infuriating, others are genuinely brilliant, and provide functionality that makes the program indispensable to any serious video encoder.

BUT WAIT, THERE'S MORE COOL STUFF!

DVD RIPPING HandBrake doesn't just rip from single video files; it also supports DVDs. You can find your disc if you look around in the "Source" window, or choose your disc drive under the "File" menu. Of course, we respect copyright here at *Maximum PC*, and assume you have legal rights over anything you rip in your locality.

CHAPTER MARKERS If you look under the "Chapters" tab, you can add, customize, and even label your own chapters to give your file that extra professional touch.

GRAYSCALE Check this option and your video is converted to black and white. This is perfect for adding some moodiness to your movies or helping young film students be pretentious.

DEVICE PRESETS To quote the website's feature list: "Get started with HandBrake in seconds by choosing a profile optimized for your device, or choose a universal profile for standard or high-quality conversions. Simple, easy, fast. For those that want more choice, tweak many basic and advanced options to improve your encodes." We didn't know that encode was a noun, but there you go. Apparently, HandBrake has presets for all kinds of devices, such as iPhones, Android tablets, the PlayStation 3, and even AppleTV.

Tighten Up Your Computer Security

YOU'LL NEED THIS

BITDEFENDER
Grab the free version of the antivirus app from www.bitdefender.com.

EVER SINCE WINDOWS 8, Windows Defender has been provided as a built-in component of the operating system, protecting against malware. However, there's a lot to be said for getting add-on third-party protection for your computer. This doesn't necessarily have to be paid for, because there are some good free options around. Naturally, the companies involved hope you'll like the product so much that you'll upgrade to the paid-for version.

One of the top free packages is by Bitdefender, and it's this that we're looking at right here. While the free edition of Bitdefender is more than adequate with antivirus scanning, anti-phishing technology, and ransomware protection, the paid-for version of Bitdefender—called Antivirus Plus—also includes a VPN, a password manager, and different modes for different purposes, such as reducing the number of notifications you receive when working or watching movies. It's the free version we're looking at here. **–DAN GRABHAM**

1 DOWNLOAD BITDEFENDER

The free version of Bitdefender will protect you against all the key online threats, and it's easy to download, install, and use. Go to www.bitdefender.com/solutions/free.html to get hold of it, and click the "Free Download" button [**Image A**]. Bitdefender Antivirus Free will stay updated, so you'll always have protection against the latest threats—updates happen automatically in the background.

2 DO YOU WANT TO UPGRADE?

Should you wish to, you can upgrade to the paid version of Bitdefender antivirus at this point. This includes a VPN, so you can encrypt all your web browsing, as well as a useful password manager. For basic use, Bitdefender Antivirus Free offers more than enough protection. If you're a gamer, it may well be worth considering the paid-for version, because there is a game mode.

3 DOWNLOAD AND RUN

The Bitdefender installation file will download [**Image B**]. If you're in Microsoft Edge, you're shown the dialog at the bottom of this window that enables you to run the installation file as soon as it has downloaded. If you're using Chrome, you need to click the file in the bar at the bottom of your browser window to start the install (or click on the file itself in your Downloads folder).

4 INSTALL BITDEFENDER

The file you downloaded is just the installer. Before it can fully install, Bitdefender downloads a much larger install file that may take a while. Ours was 354MB. If you have a very slow connection, we recommend doing this part overnight. If you have a fast connection, it should be no problem, however, and the app tells you how far through the process it is.

5 SCAN FOR THE FIRST TIME

As it installs, Bitdefender scans your system for the first time [**Image C**]. This is to ensure there are no big identifiable issues with your system. After all, many people only download software like Bitdefender Antivirus Free when they actually have a problem with their PC, so it makes sense for the program to check that all is well with your computer from the get-go.

6 CREATE OR SIGN IN TO YOUR ACCOUNT

To use Bitdefender Antivirus Free, you need to have a Bitdefender account. Enter your name and email address, and create a password if you don't already have an account [**Image D**]—don't enter false details, because Bitdefender emails you to confirm your email address is legitimate. You need to click the link in the email to confirm your account, and prove your email address is yours.

7 YOU'RE PROTECTED!

If you don't see the main window for Bitdefender Antivirus Free [**Image E**], check for the "B" icon in your notifications area, on the right of your Taskbar—it may be hidden behind the drop-down arrow. Once you see the icon, click it to open the Bitdefender window. As you can see, you're now protected from any threats. You can click to start a system scan should you want to check your PC.

8 FINISHED SCANNING

When the scan has finished, you'll see this in the status area below. You can drag and drop any file to the Bitdefender window to manually check it [**Image F**]. As you can see, the app has also performed an update. Bitdefender won't necessarily let you know when it's doing things like this, but notifications appear in the status area. Security apps like Bitdefender are designed to run in the background.

9 GO TO SETTINGS

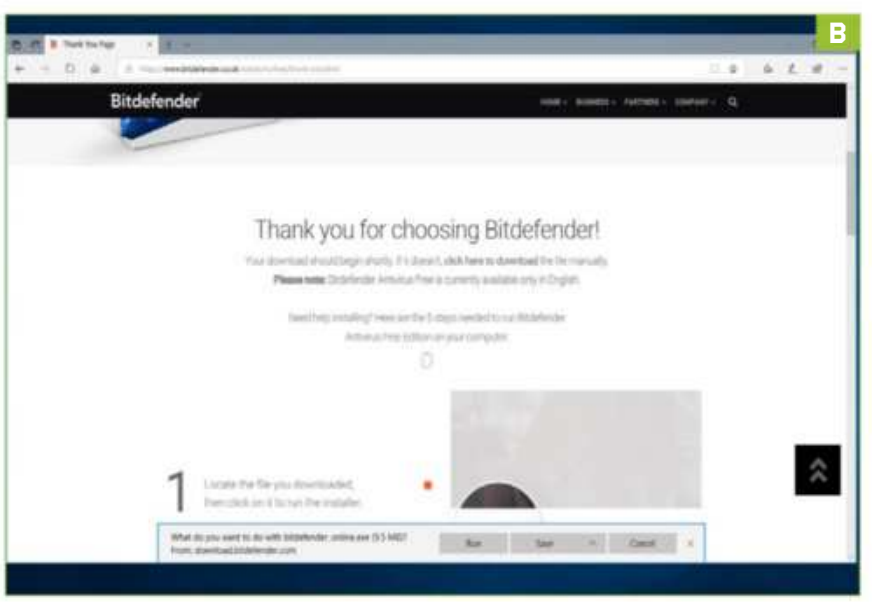
Click the cog icon in the top-right of the window to access Bitdefender's settings. From here, you can view all the "events" that have occurred. You can also choose whether to turn the Protection Shield on or off [**Image G**]—this automatically blocks malicious files. You can turn it off if it identifies a problem with something that you know is legitimate.

10 HELP AND MORE

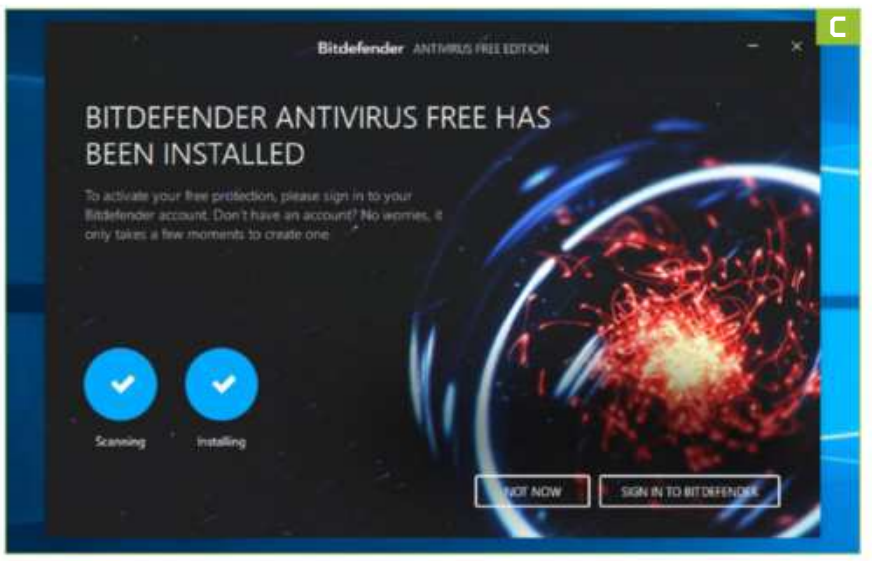
If you have an issue with Bitdefender Antivirus Free, you can search the help pages at the Bitdefender website, although most things should be fairly self-explanatory. You will need to upgrade the software should you need more in-depth support. You're also able to send in any feedback you want to relay using the handy link [**Image H**]. Again, this window is accessed via Bitdefender's "Settings" menu.

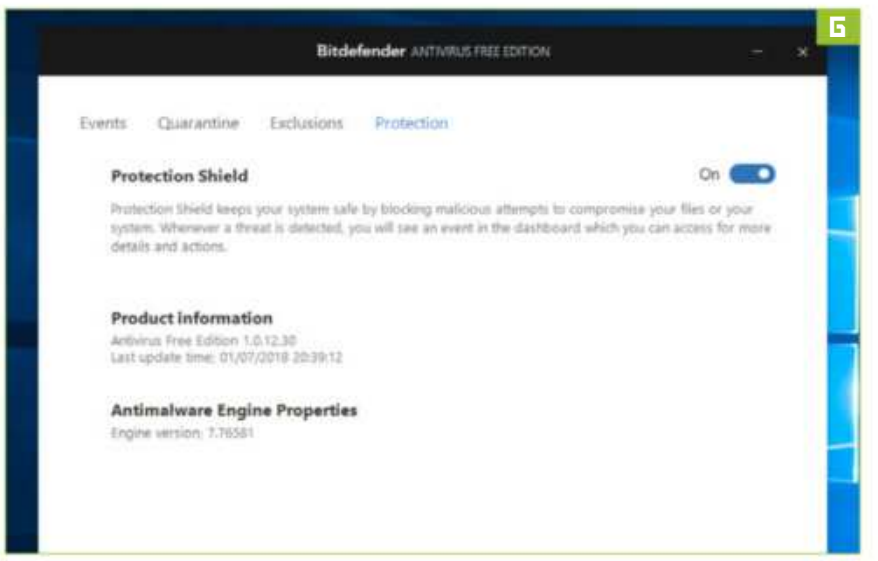
A
Bitdefender
Bitdefender
Antivirus Free Edition
Powerful antivirus protection, the light way

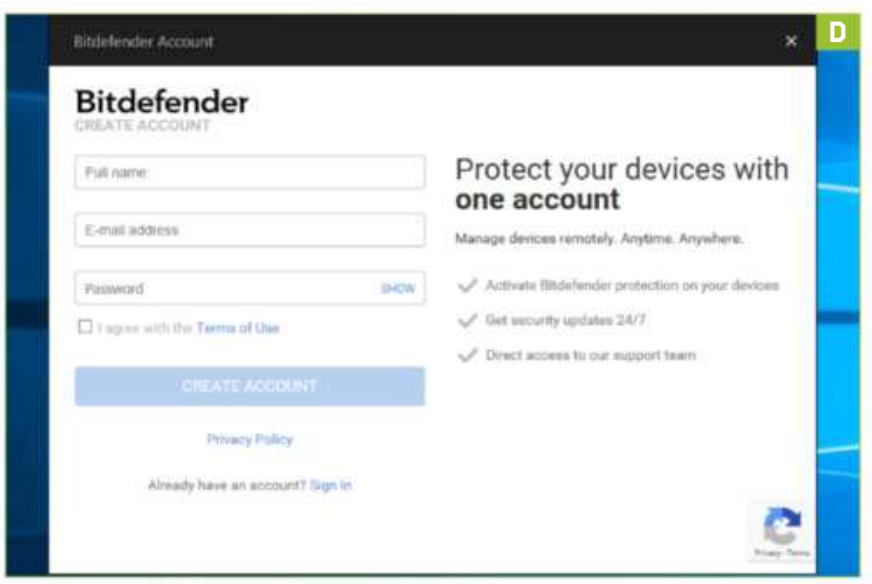
E
YOUR DEVICE IS
PROTECTED
SYSTEM SCAN
Drag and drop any file or folder here to start scanning
System scan in progress (1%)
c:\users\xps 13\dropbox\camera uploads\2016-09-17 16.21 ...
Update finished
Update successfully finished.

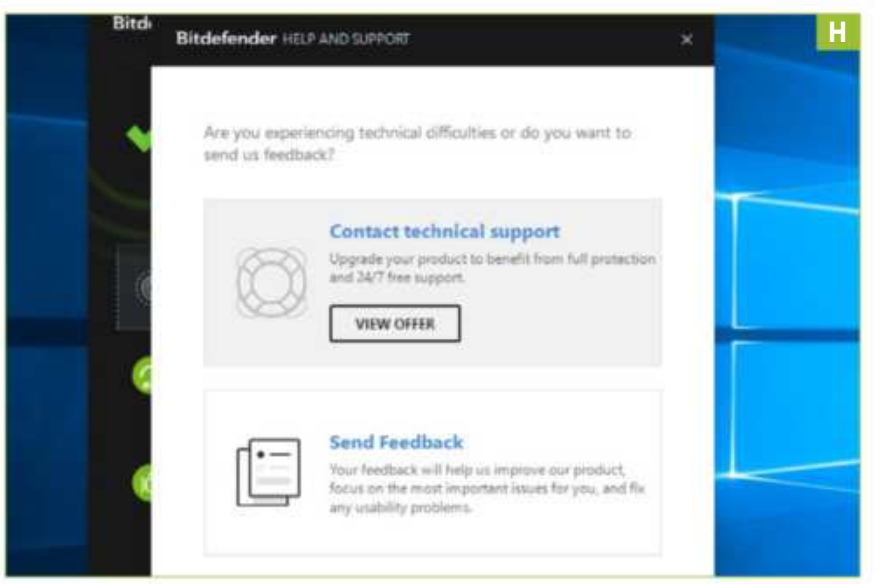

B
Bitdefender
Thank you for choosing Bitdefender!

F
YOUR DEVICE IS
PROTECTED
SYSTEM SCAN
Drag and drop any file or folder here to start scanning
Update finished
Update successfully finished.
System scan
Scanned 367012 items and detected 0 threats.


C
Bitdefender ANTIVIRUS FREE EDITION
BITDEFENDER ANTIVIRUS FREE HAS BEEN INSTALLED
To activate your free protection, please sign in to your Bitdefender account. Don't have an account? No worries, it only takes a few moments to create one
Scanning
Installing
NOT NOW
SIGN IN TO BITDEFENDER


G
Bitdefender ANTIVIRUS FREE EDITION
Events
Quarantine
Exclusions
Protection
Protection Shield
On
Protection Shield keeps your system safe by blocking malicious attempts to compromise your files or your system. Whenever a threat is detected, you will see an event in the dashboard which you can access for more details and actions.
Product information
Antivirus Free Edition 1.0.12.30
Last update time: 01/07/2018 20:39:12
Antimalware Engine Properties
Engine version: 7.76581


D
Bitdefender Account
Bitdefender
CREATE ACCOUNT
Full name
E-mail address
Password
SHOW
I agree with the Terms of Use
CREATE ACCOUNT
Privacy Policy
Already have an account? Sign in
Protect your devices with one account
Manage devices remotely. Anytime. Anywhere.
Activate Bitdefender protection on your devices
Get security updates 24/7
Direct access to our support team


H
Bitdefender HELP AND SUPPORT
Are you experiencing technical difficulties or do you want to send us feedback?
Contact technical support
Upgrade your product to benefit from full protection and 24/7 free support.
VIEW OFFER
Send Feedback
Your feedback will help us improve our product, focus on the most important issues for you, and fix any usability problems.

Eliminate Digital Distractions

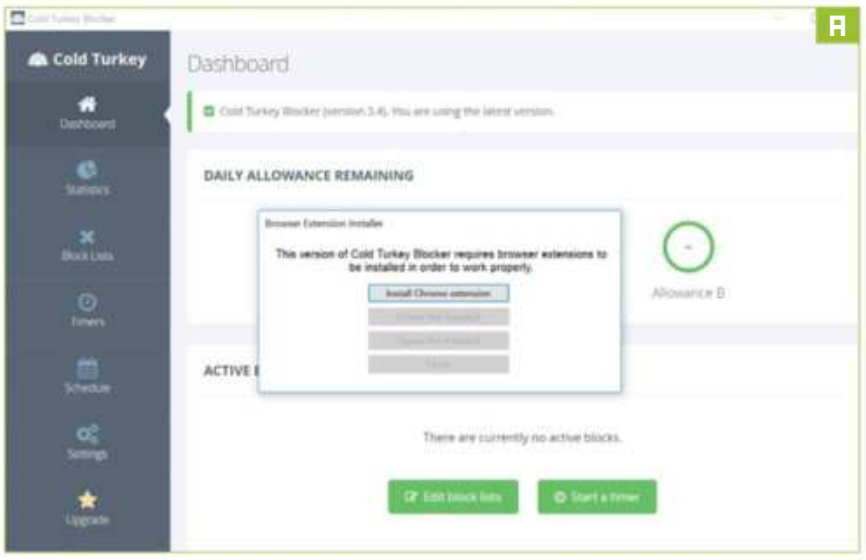
YOU'LL NEED THIS

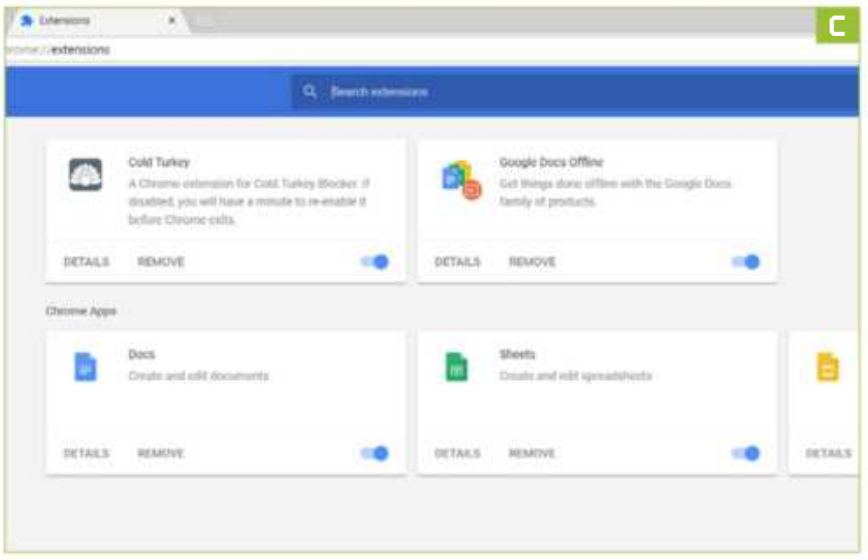
COLD TURKEY BLOCKER

Download the software from https://getcoldturkey.com.

IT'S VERY EASY TO FALL down an online rabbit hole: You start the day with the best intentions, but before you know it, you've spent three hours watching pop videos on YouTube. That's great if you're just messing around, but it's a problem if you're messing around when you really ought to be working. Cold Turkey Blocker makes it impossible to mess about for a specified time.

Windows 10's built-in parental controls cover similar ground, such as setting time limits, but Cold Turkey Blocker is even tougher: It works across web browsers and with virtual private networks, and if you decide to shell out for the paid-for Pro version, you get some really advanced blocking tools. But, as we'll discover in this tutorial, the free version does an incredibly good job of getting rid of the biggest time-wasters and keeping you focused on what you're supposed to be doing. –**CARRIE MARSHALL**


A
Cold Turkey
Dashboard
DAILY ALLOWANCE REMAINING
This version of Cold Turkey Blocker requires browser extensions to be installed in order to work properly.
Install Chrome extension
There are currently no active blocks.
Edit block lists
Start a timer

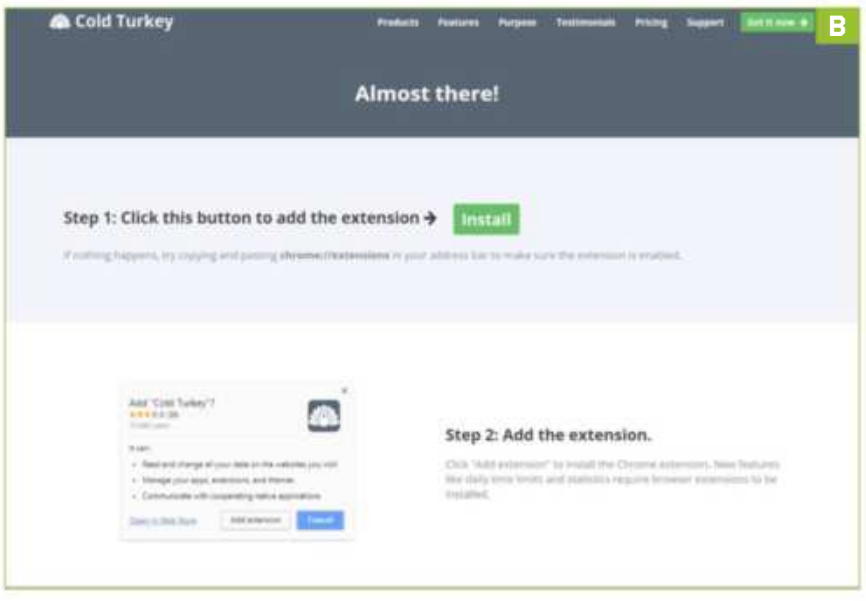


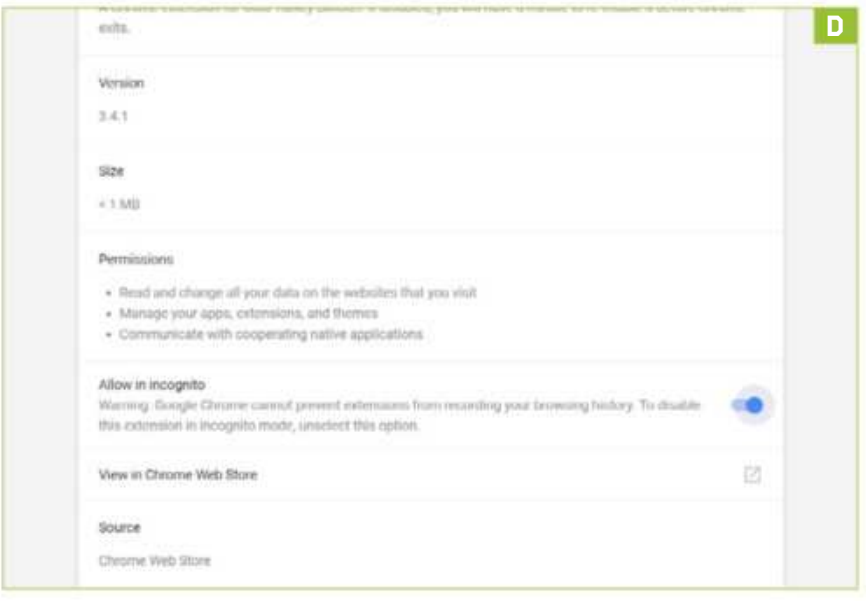
1 WHICH EXTENSION DO YOU REQUIRE?

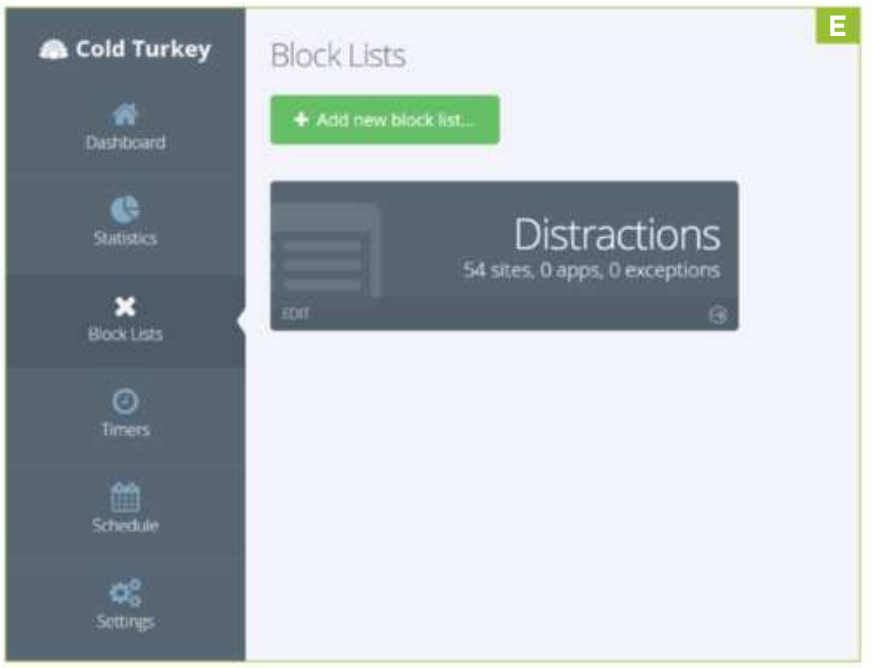
The first time you install the Cold Turkey Blocker program on your system, you also need to install the appropriate extension for Google Chrome (or whatever web browser you're using) as well [**Image A**]. Cold Turkey Blocker offers support for both Firefox and Opera, too—however, unfortunately it currently doesn't work with the latest version of Microsoft's Edge browser. Unless you're a die-hard Edge fan, we always recommend that you go with an alternative browser anyway. And in this case, you'll just have to stop yourself from being tempted to use Edge in order to circumvent the blocking.

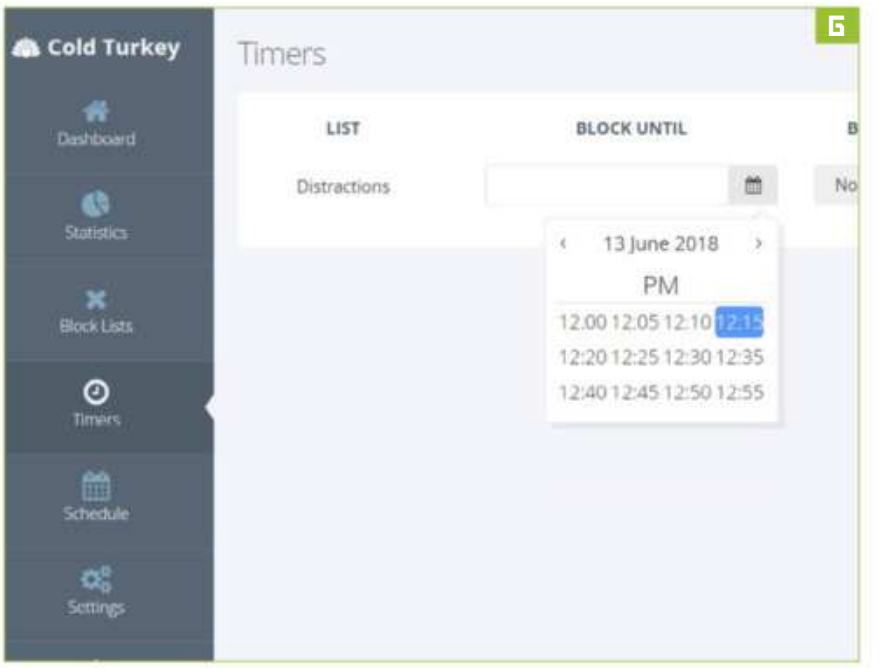
2 INSTALL THE APP

First up, you're obviously going to need to get yourself the free version of Cold Turkey Blocker, so go to https://getcoldturkey.com, click the big green "Get it now" button, then click "Download Now" to grab the "Basic" version. Once Cold Turkey is installed on your system, run the program, and it asks you which browser extension you want to install. Click the green "Install" button in the new window that appears [**Image B**], and it installs and adds the extension to your Chrome, Opera, or Firefox browser for you.









3 ENABLE THE EXTENSION

The first thing you need to do is enable the extension, which you do by clicking the "On/Off" button, so it's no longer gray. You can get to this page any time by entering "chrome://extensions" in the address bar [**Image C**]. You also need to click the "Details" link underneath the Cold Turkey icon, because there's an important setting we need to switch on for the app.

4 ENABLE INCOGNITO

Just below the halfway mark in the extension details menu, you should see an option for "Allow in incognito" [**Image D**]. This needs to be enabled, or you or anybody else can bypass Cold Turkey by putting Chrome into incognito mode, its private browsing mode. If you don't enable this option, Cold Turkey automatically closes Chrome after one minute whenever you launch it, in order to prevent any potentially unwanted shenanigans.

5 DETAIL THE DISTRACTIONS

Once you've changed it so Cold Turkey can now function in incognito mode, you can return to the desktop app. From the Dashboard screen, click "Block Lists" [**Image E**] to start finding ways to make your day distraction-free. By default, Cold Turkey Blocker comes with a predefined list of time-wasting websites, such as Netflix, discussion boards, and clickbait websites. Click "Edit" to see the block list or to add your own entries.

6 CUSTOMIZE THE LIST

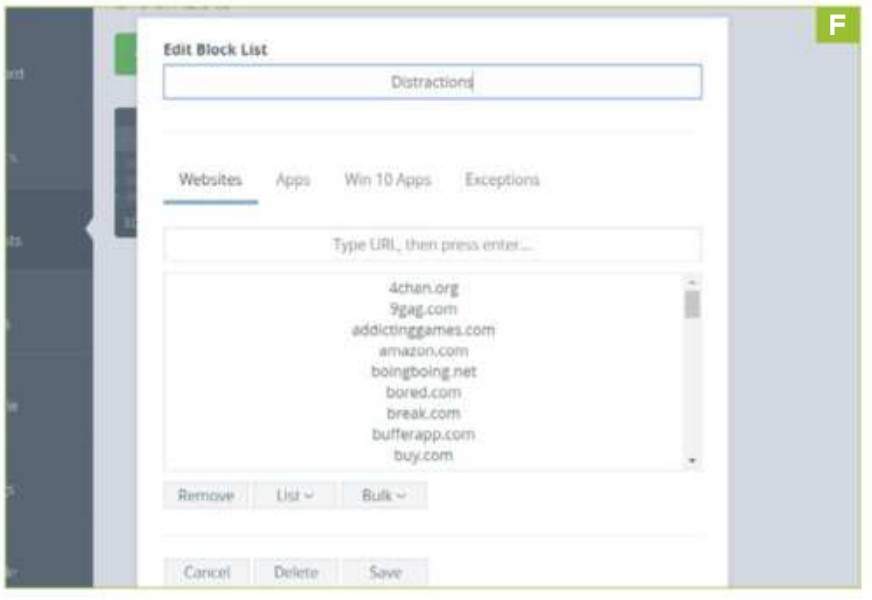
If you drop the cash on the Pro version, you'll see four categories toward the top of the window here: "Websites," "Apps," "Win 10 Apps," which blocks apps that aren't EXE files, and "Exceptions" [**Image F**]. You can use the last one to whitelist certain web pages and programs. For example, you might want to block Reddit, but still allow yourself access to http://reddit.com/r/getmotivated. It's a nifty little feature, although it does make the program a little inflexible without spending money first. It's currently $19 for the Pro version as a one-off payment.

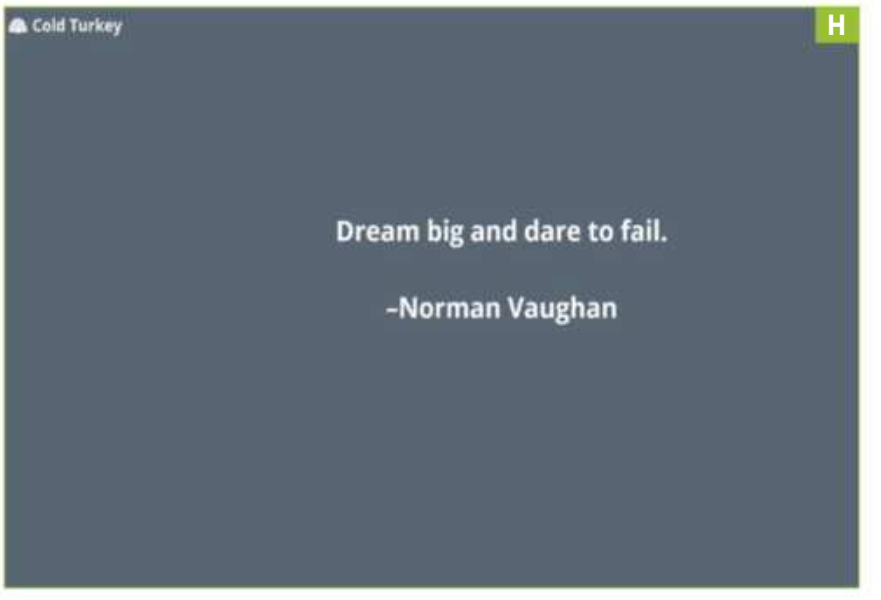
7 SET THE BLOCK

Now we've got the exceptions edited, it's time to set the block. Click the "Timers" icon to set the end time for your distraction-free session. From the main dashboard, click "Start a timer," then click the Calendar under "Block Until." Next, click the date, then click the time you want the distraction-free period to finish [**Image G**]. Only click the big "Status" toggle button from "Off" to "On" when you're sure you have the right date and time set for your distraction free period.

8 TURN IT ON

Once everything's set up, and you've pressed the big red button, so to speak, with the filters and timers switched on, this is what happens when someone—including you—tries to visit any of the sites you've limited access to: Instead of Netflix, for example, we get a motivational quote designed to encourage us to be more productive [**Image H**]. The message appears with any access attempts, until the distraction-free period ends.





Tame Your Browser Tabs With Toby

YOU'LL NEED THIS

TOBY
Create an account and add the extension to your browser at http://gettoby.com.

WE ALL DO IT: We open one web browser tab, then another, then a whole bunch more. Before we know it, our computer is wheezing under the strain of so many open browser tabs, we can't find the website we were looking at 10 seconds ago, and the tab bar has become totally incomprehensible. And if the browser crashes....

Thank goodness for Toby. Toby is a browser extension for Chrome, Opera, or Firefox that you can use to tame your browser tabs in two ways. First, you can use it to organize groups of tabs into "collections," which you can then open with a single click later. For example, you might have a collection for news sites, or for entertainment, or for work stuff. And second, you can use the Toby extension to save all the currently open tabs, so you can access them again later. As you'll discover, Toby is very useful, but it isn't hard to set up or use. –CARRIE MARSHALL

1 INSTALL THE EXTENSION

Toby doesn't work on Microsoft Edge, but it is available for Chrome, Firefox, and Opera. The first thing to do is create an account at http://gettoby.com. This enables you to sync your bookmarks with Toby's servers in case of a browser crash (and between different devices, if you have more than one computer—which is a useful thing to have on its own). Invite friends to use Toby and you'll unlock a dark theme, too, although this obviously isn't essential to getting started, and actually seems like an odd thing to include when you're using something new for the first time. Click "Add Extension" to install it [**Image A**].

2 OPEN SOME SITES

The easiest way to get started with Toby is to open a selection of websites, each one in its own tab. If you click the "New Tab" button to the right of the rightmost tab, you should see this screen [**Image B**]. Your browser may complain about the fact that an extension is changing what you're seeing when you open a new tab for browsing, but that's fine here, because it's you that's changing how you use your browser. Toby isn't usually shocking pink, by the way; this color scheme is just used at the beginning to help you get started, by highlighting the key parts of the interface. As the prompt suggests, click the "+" icon to start your first collection.

3 CHOOSE A GOOD NAME

You can store multiple collections of sites, so it's a good idea to give any collection a meaningful and distinct name, so that it's clear what sites it contains. Try to be specific, too, as your sections will grow as you use it, and generic titles such as "News" can be too all-encompassing. Here we're going to go for "Amazing tech news," because we're going to collect a selection of technology websites. You should see another prompt, this time to drag "How to use Toby" to your new collection [**Image C**]. Drag it just under your collection's title, and the pink hue should disappear.

4 START YOUR COLLECTION

You should now see the "How to use Toby" tab underneath your collection's title [**Image D**]. If you look to the right of the browser window, you'll see rectangles for all your other open browser tabs. To add them to the current collection, simply select and drag them one at a time into your "Amazing tech news" section, just to the right of the "How to use Toby" entry. Each one should appear in the collection with a preview of its content. You can change the order of the sites by dragging them around.

5 FINISH YOUR COLLECTION

As you drag a site from the right of the screen, it disappears from the list of open tabs, and if you look at the tab bar at the top of the browser window, you'll see those tabs have closed, too. That's entirely deliberate: Toby's goal is to close tabs until you actually need them. It can be a little hard to see, but there's an "Open Tabs" link at the right of your collection [**Image E**]. Clicking this button opens all the tabs from that collection. Pressing it again opens all the tabs a second time—although this has no useful benefit, it does highlight how Toby works. You can close those tabs using the list on the right, or by simply closing the tabs as normal.

6 MAKE SOME MORE

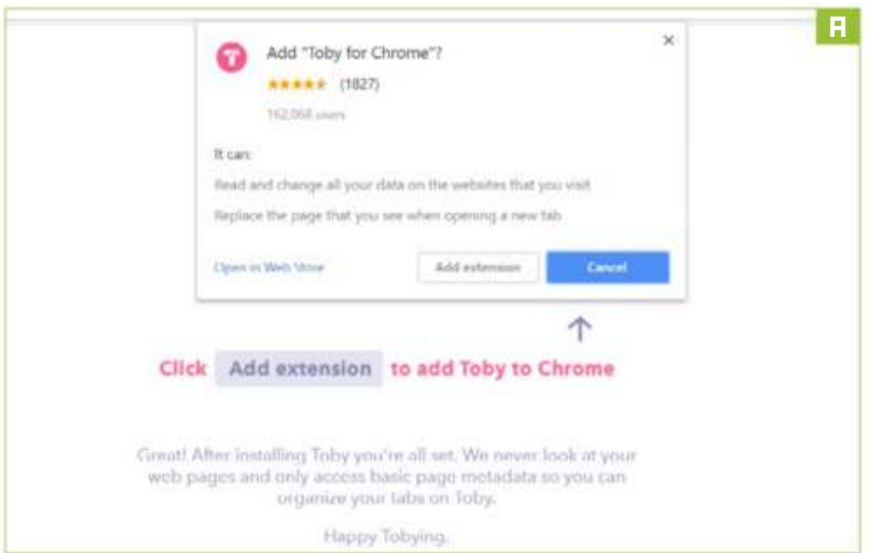
You can have different collections for all kinds of things and group them by subject—as we've done here [**Image F**]—or on a per-job or per-task basis. So, for example, if you were researching a project, you might create a collection for all your research documents. You can edit the collection's title or delete it altogether by clicking the icon with three vertical dots at the right of the collection. This can be useful as the nuances of your collections appear—as you drill down into particular subjects, say, but want to keep the original grouping.

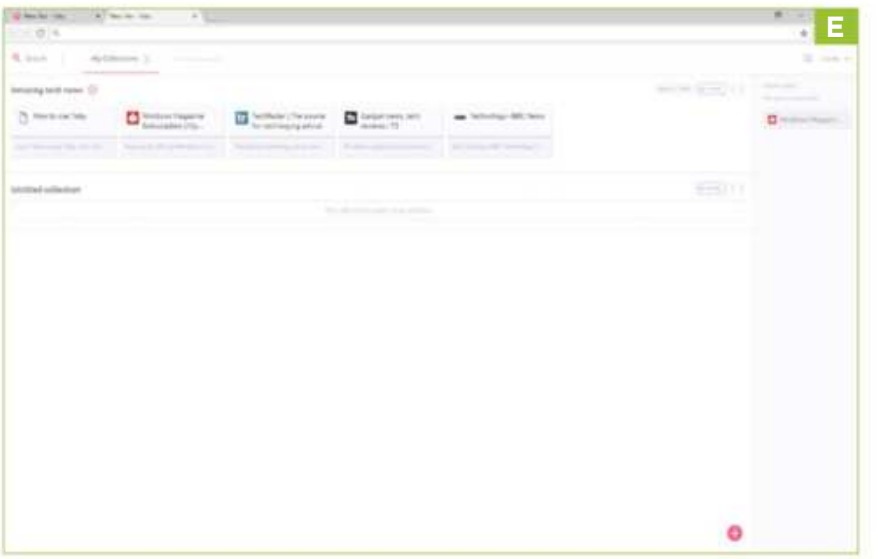
7 USE YOUR COLLECTION

Once you've created one or more collections, you'll see them listed whenever you open a new browser tab. You can then click the "Open Tabs" link to open the contents of that collection [**Image G**], or you can click the "Share" link to send the tabs to somebody else. The little arrows next to the "Share" link enable you to re-order your collections on the "New Tab" screen by moving them up or down.

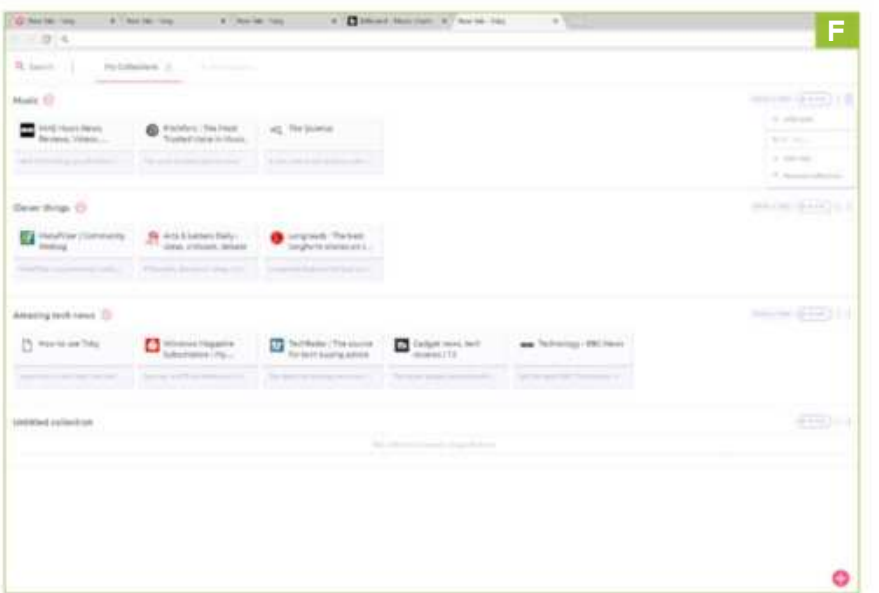
8 SAVE YOUR SESSION

Toby has another excellent trick up its sleeve: It adds a little icon to the far-right of Chrome's address bar that enables you to open Toby or save the tabs in your current session [**Image H**]. That latter option saves all your open browser tabs, so you can return and relaunch them later. There's also a handy search field that you can use to find something specific in your saved collections.


A
Add "Toby for Chrome"?
(1827)
162,068 users
It can:
Read and change all your data on the websites that you visit
Replace the page that you see when opening a new tab
Open in Web Store
Add extension
Cancel
Click Add extension to add Toby to Chrome
Great! After installing Toby you're all set. We never look at your web pages and only access basic page metadata so you can organize your tabs on Toby.
Happy Tobying.


E

B
Create your first collection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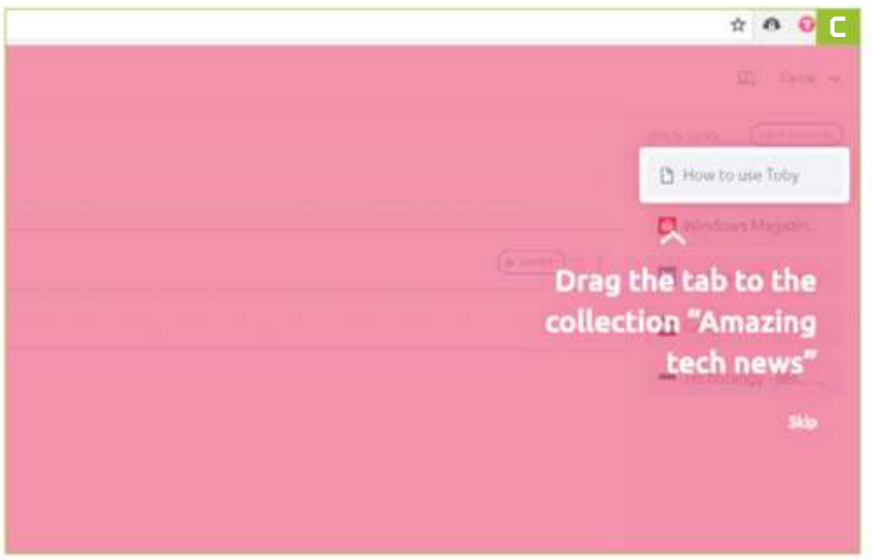
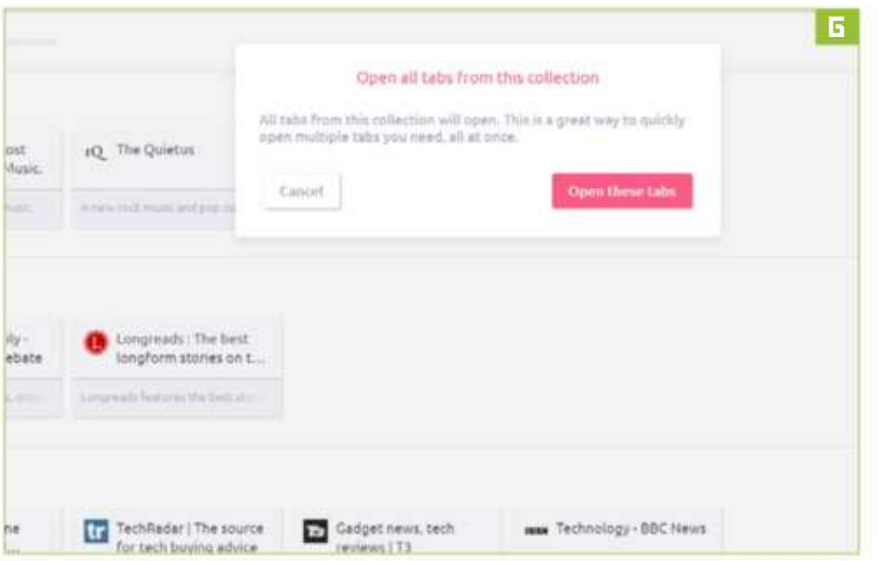
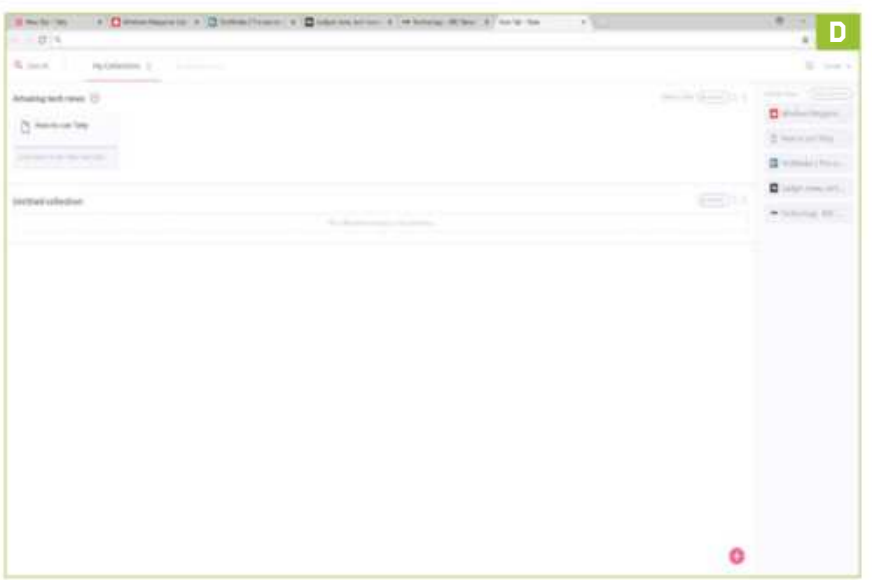
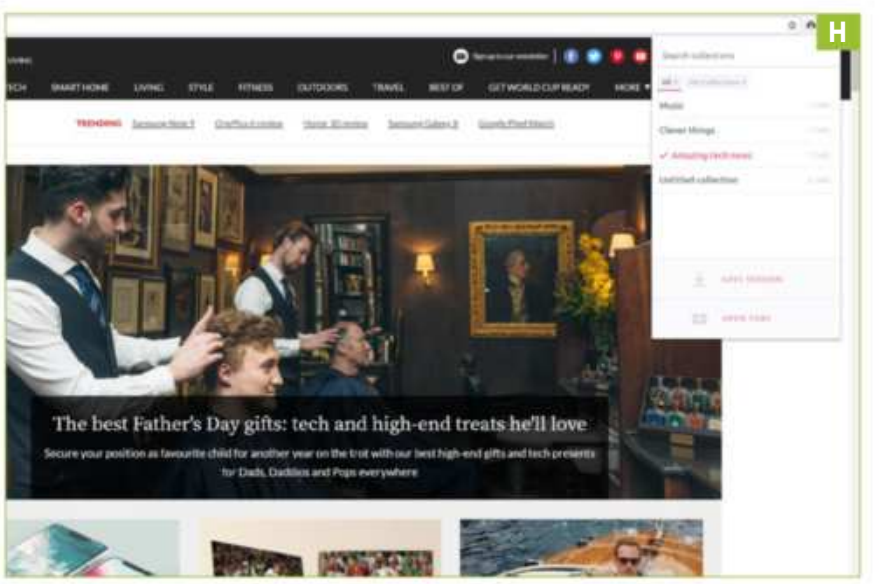

C
How to use Toby
Drag the tab to the collection "Amazing tech news"
Skip


G
Open all tabs from this collection
All tabs from this collection will open. This is a great way to quickly open multiple tabs you need, all at once.
Cancel
Open these tabs
The Quietus
Longreads | The best longform stories on t...
TechRadar | The source for tech buying advice
Gadget news, tech reviews | T3
Technology - BBC News


D


H
The best Father's Day gifts: tech and high-end treats he'll love
Secure your position as favourite child for another year on the trot with our best high-end gifts and tech presents for Dads, Daddios and Pops everywhere

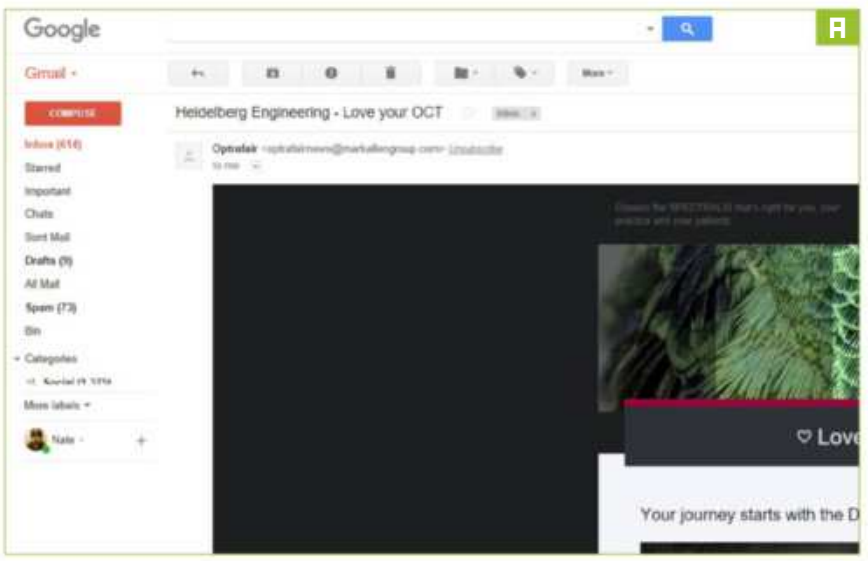
Clean Up Your Gmail Inbox

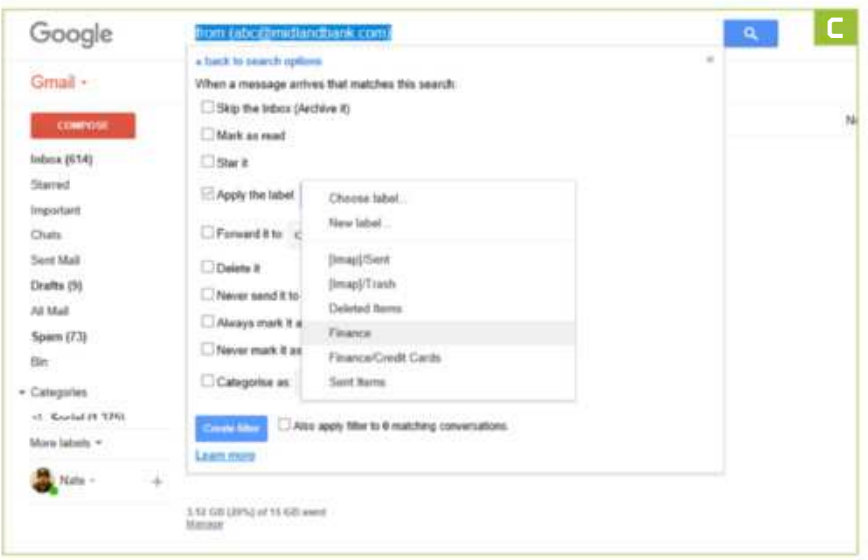
YOU'LL NEED THIS

GMAIL ACCOUNT
With a bulging inbox.

GMAIL USERS ENJOY A GENEROUS INBOX quota of over 15GB. While space is unlikely to be a concern, it can be tricky to sift through a mounting pile of messages. Google has tried to address this problem by automatically marking certain messages as "important," and sorting your mail into five broad categories: Primary, Social, Promotions, Updates, and Forums. There's also an advanced junk mail filter.

These measures may not be enough for a Gmail account that's truly bulging at the seams, however, so in this guide, you'll learn how to sort messages using smart labels, as well as how to mass delete and filter unwanted content. We'll also show you how to mark all emails as read, and archive older content. Plus, you'll learn advanced search techniques, such as looking at mail received before a certain date. **–NATE DRAKE**



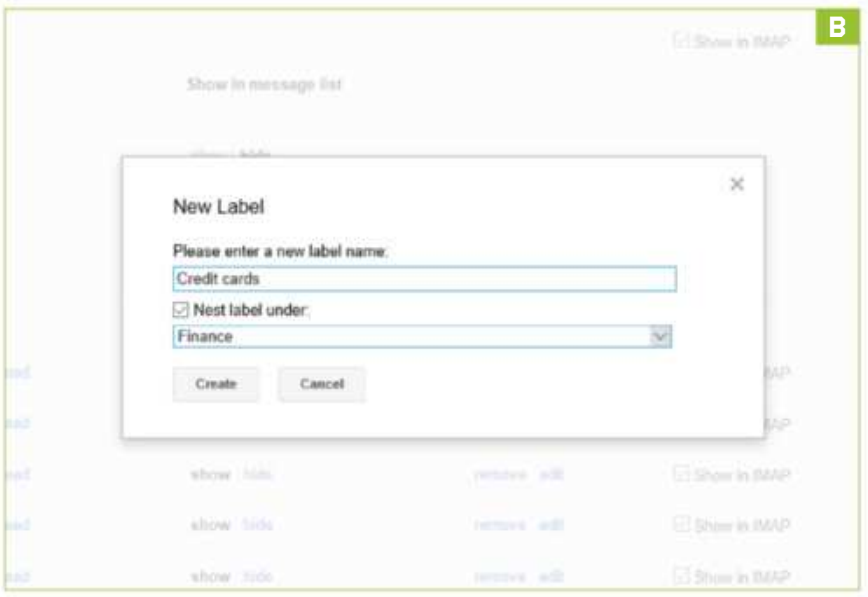


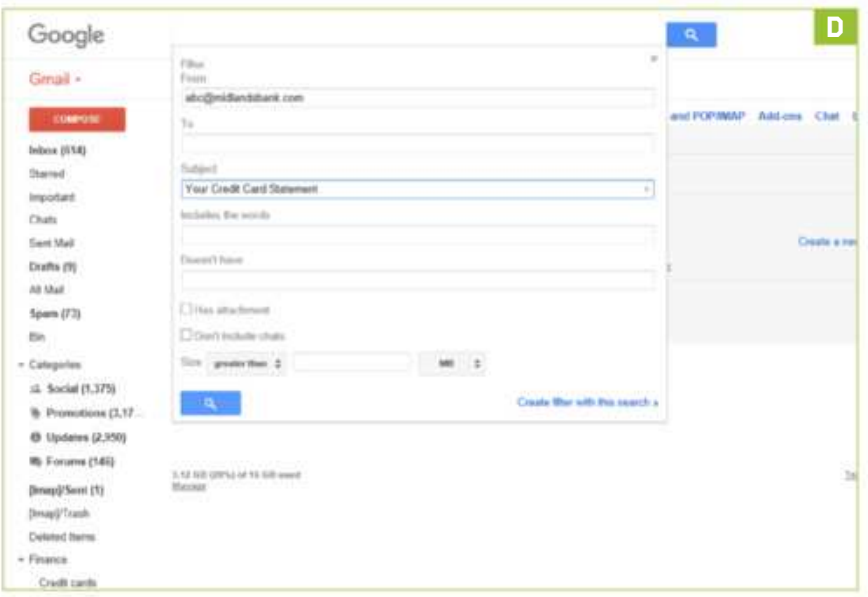
1 UNSUBSCRIBE AND REPORT

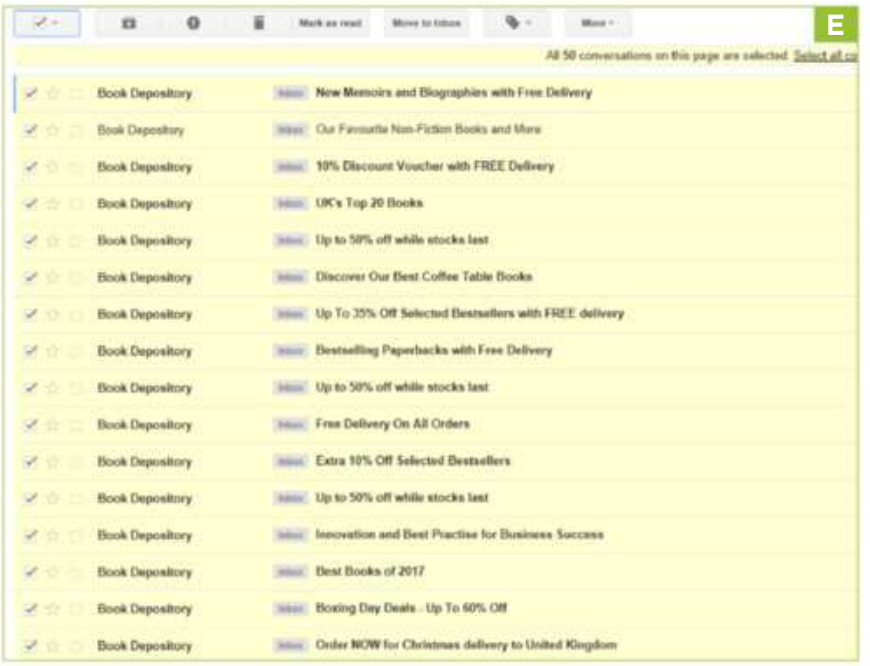
Gmail [**Image A**] helpfully sorts your incoming emails into separate categories. There are three tabs overall—Primary, Social, and Promotions—and Google automatically organizes your emails, depending on what it believes the content of the messages is related to. Normal and important emails fall under Primary, any social media or forum notifications fall into Social, and advertising or commerce-related emails fall into Promotions. Click through the Promotions and Social sections, and unsubscribe to any content that you no longer want to see. Gmail does its best to protect you from junk.

2 USE LABELS

Labels are a powerful way to manage your messages. They act like traditional email folders in that you can drag messages into a certain category—"Vacation 2018," for example. To do that, click the drop-down menu in the left-hand column, and select "Create new label." Then enter the field name you wish to use. You can even have sub-labels within labels, and use them to divide things up. To do this check the "Nest label under" box, and then choose from the drop-down where you want the new label to be placed [**Image B**].






E
All 50 conversations on this page are selected. Select all co
Book Depository New Memoirs and Biographies with Free Delivery
Book Depository Our Favourite Non-Fiction Books and More
Book Depository 10% Discount Voucher with FREE Delivery
Book Depository UK's Top 20 Books
Book Depository Up to 50% off while stocks last
Book Depository Discover Our Best Coffee Table Books
Book Depository Up To 35% Off Selected Bestsellers with FREE delivery
Book Depository Bestselling Paperbacks with Free Delivery
Book Depository Up to 50% off while stocks last
Book Depository Free Delivery On All Orders
Book Depository Extra 10% Off Selected Bestsellers
Book Depository Up to 50% off while stocks last
Book Depository Innovation and Best Practise for Business Success
Book Depository Best Books of 2017
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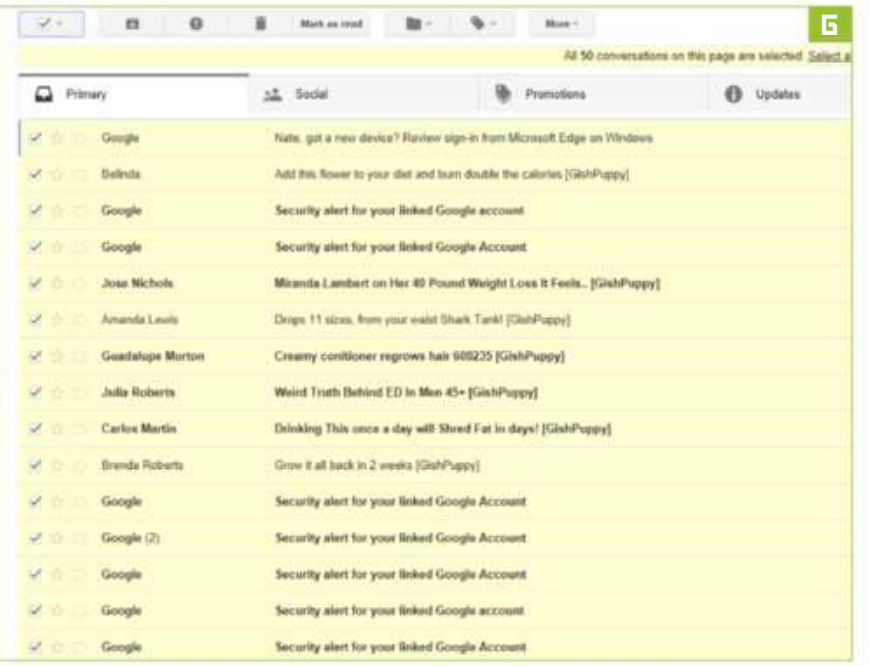
Book Depository Order NOW for Christmas delivery to United Kingdom


G
All 50 conversations on this page are selected. Select a
Primary
Social
Promotions
Updates
Google Nate, got a new device? Review sign-in from Microsoft Edge on Windows
Belinda Add this flower to your diet and burn double the calories [GlishPuppy]
Google Security alert for your linked Google account
Google Security alert for your linked Google Account
Jose Nichols Miranda Lambert on Her 40 Pound Weight Loss It Feels.. [GlishPuppy]
Amanda Lewis Drops 11 sizes from your waist Shark Tank! [GlishPuppy]
Guadalupe Morton Creamy conditioner regrows hair 605235 [GlishPuppy]
Julia Roberts Weird Truth Behind ED In Men 45+ [GlishPuppy]
Carlos Martin Drinking This once a day will Shred Fat in days! [GlishPuppy]
Brenda Roberts Grow it all back in 2 weeks [GlishPuppy]
Google Security alert for your linked Google Account
Google (2) Security alert for your linked Google Account
Google Security alert for your linked Google Account
Google Security alert for your linked Google account
Google Security alert for your linked Google Account

3 BASIC FILTERING

Labels can be very handy, but it's a nuisance categorizing emails each time they come in. Fortunately, Gmail can apply filters. Click the drop-down menu in the search bar, then enter the details you want to find in the emails (including who it's from, who the email was to, and even words used within the email), then hit "Create filter" [**Image C**]. Once here, you can choose what to do to the messages, including applying the label, categorizing them, or even just searching for them.

4 ADVANCED FILTERS

Gmail can do more than just label messages from a specific sender. This can be useful if, for example, you want to find credit card statements sent from your bank, but aren't interested in the marketing messages it sends out. To get started, create a new filter, as outlined in the previous step, but this time fully explore the options—you can filter by the subject of the email using the "Subject" field, for example [**Image D**].

5 MASS-DELETE EMAILS

If you've found a message you want to delete, Gmail can help you delete others like it. Use the search bar to do this. You can find emails from specific senders—"from: sales@marvinsmagic_pills.xyz," for example. Next, check the box at the top-left, then hit the trash icon at the top of the screen to delete all of the emails from that particular sender [**Image E**]. If you mess up, don't worry, it's not all lost. Your deleted emails simply sit in your "Bin" section of Gmail for 30 days before they are permanently deleted.

6 BLOCK UNWANTED EMAILS

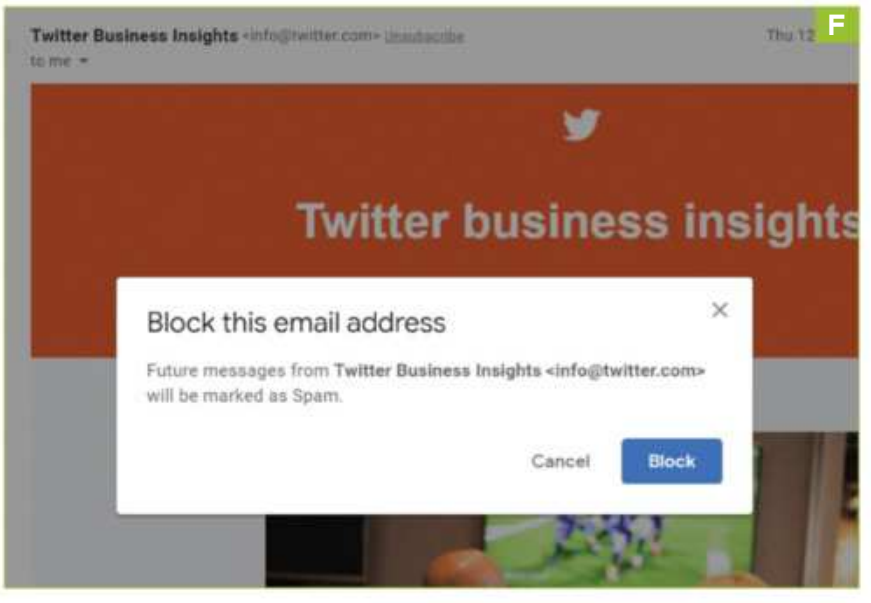
Deleting unwanted messages makes your inbox tidier, but doesn't prevent the sender from emailing you again in the future. Luckily, Gmail has a feature for blocking unwelcome emails: Open any email from an undesirable sender, choose the drop-down option beside the "Reply" button, then click "Block" [**Image F**]. Blocked senders appear under the "Filters and blocked addresses" Gmail setting.

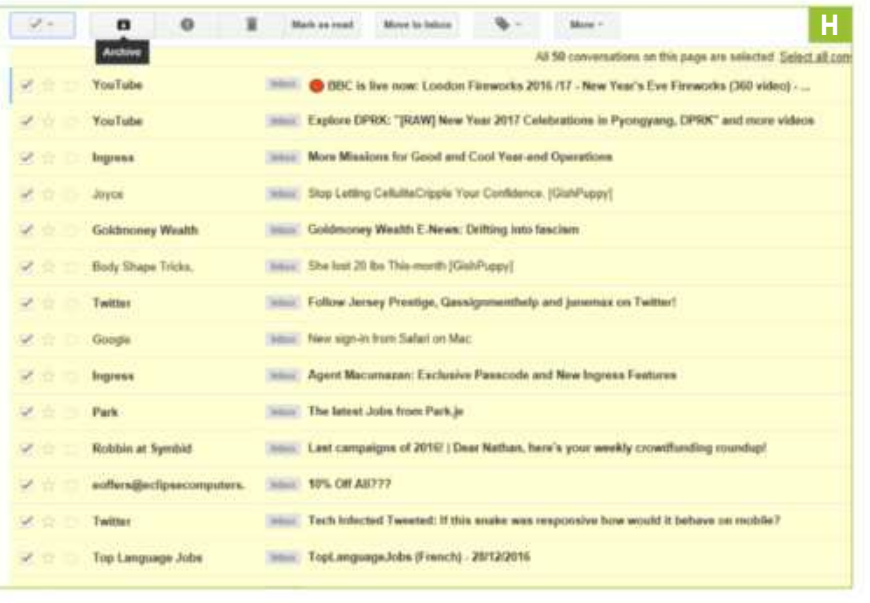
7 MARK ALL MESSAGES AS READ

Gmail automatically displays the number of unread messages beside your inbox. As junk mail mounts, it's hard to keep track of important messages. To reset your unread message count to zero, check the "Select all" box (top-left), then click the three dots on the far right of it to open the drop-down menu. Next, click "Mark as read" [**Image G**]. If you use category tabs—Primary, for example—you'll need to do this for each one.

8 ARCHIVE MESSAGES

You probably have some emails cluttering up your inbox that are too important to delete. Gmail enables you to archive them—they're moved from the inbox and stored in "All Mail" instead. Right-click an email you wish to archive from the main inbox (or any tab, for that matter), then select the "Archive" option. You can also do this en masse, by selecting several emails, using the check box, then hitting "Archive" at the top [**Image H**].




H
Archive
All 50 conversations on this page are selected. Select all con
YouTube BBC is live now: London Fireworks 2016 /17 - New Year's Eve Fireworks (360 video) - ...
YouTube Explore DPRK: "[RAW] New Year 2017 Celebrations in Pyongyang, DPRK" and more videos
Ingress More Missions for Good and Cool Year-end Operations
Joyce Stop Letting CelluliteCripple Your Confidence. [GlishPuppy]
Goldmoney Wealth Goldmoney Wealth E-News: Drifting into fascism
Body Shape Tricks, She lost 20 lbs This-month [GlishPuppy]
Twitter Follow Jersey Prestige, Qassignmenthelp and jamemax on Twitter!
Google New sign-in from Safari on Mac
Ingress Agent Macumazan: Exclusive Passcode and New Ingress Features
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Have Fun With Silhouettes

YOU'LL NEED THIS

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THE SILHOUETTE—a blacked-out subject contrasting against a lighter background—has been used in art for centuries. Photographers work hard to create the effect, carefully exposing an image to get the perfect balance of darkness and light, although it's as likely to be done accidentally by a bright background, such as a sky, fooling the camera's light meter.

Pliny the Elder, writing around 79AD, tells the story of Butades the potter, whose daughter was in love with a young man about to leave on a long journey. She used a lamp to throw a shadow of his profile on to a wall, and traced it so she could look at it and remember him. Butades filled in the outline with clay, creating a relief of the man's shadow, before baking it hard by the fire.

Things have moved on a bit since Pliny's time, however, and these days we don't need clay—we have digital image manipulation. We're going to look at a couple of silhouette techniques here, both of which use one of Photoshop's most powerful tools: the mask. **–IAN EVENDEN**

1 CHOOSE A PICTURE

The image you choose here is important—it needs a strong subject you can cut out, and which will still be recognizable once you've darkened it. Beloved family members posing by a lake work very well, for example, because you can easily select the water to replace it with something more dramatic. Our photo of a young lady on a jetty [**Image A**] is going to need a bit of work, because the foliage on the other side of the water creates a busy background that intersects with her hair. You'll also need to choose your dramatic background image.

2 SELECTIONS

The first thing to do is to make a selection around your subject—anything that you want to be silhouetted [**Image B**]. We used the "Quick Select" tool in conjunction with "Select and Mask," and even then had trouble with the soles of her feet and her hair. We shrank a "Quick Select" brush down to only a few pixels across, and zoomed right in to get the small details selected. For the feet, "Select and Mask" (from the "Select" menu) couldn't tell the difference between the dark areas of the model and the water, so we once again had to take matters into our own hands. Once we were happy with the selection, a bit of feathering softened the join between subject and background.

3 BACKGROUND

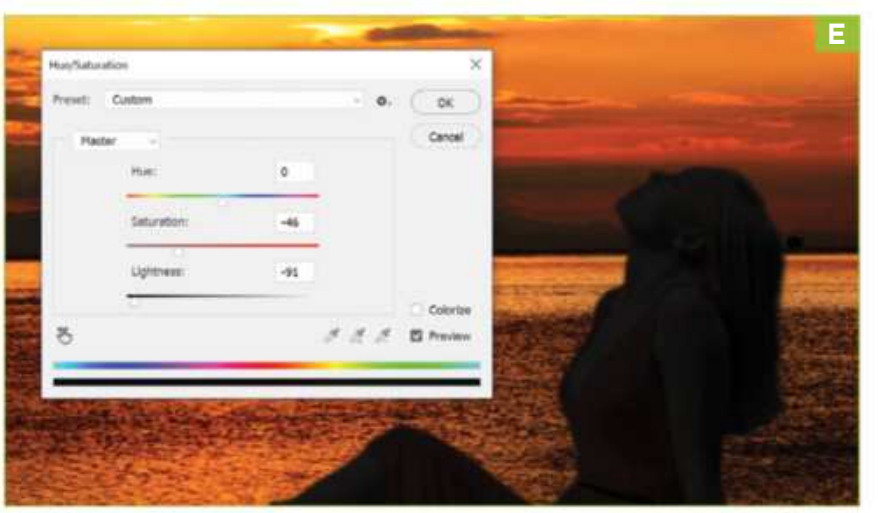
Choose a photo that's bright, colorful, and preferably taken from the same sort of angle as your subject was. If the angle is much higher or lower, you'll end up with an unrealistic result—although there are ways to tweak this. Placing your selected foreground subject against this new background is a case of importing the new image as a new layer, double-clicking your background layer to free it, moving it above the new layer in the "Layers" palette [**Image C**], inverting your selection ("Select → Inverse"), and clearing (Backspace) away the bits you don't want.

4 DOES IT FIT?

If your two photos don't line up, they can look odd. In our original photo, the join between water and land was around the level of the model's shoulders. In the composited version, the horizon is much lower, and it looks weird, as though the jetty is sticking up in the air. You can use "Content Aware Scaling" (on the "Edit" menu) with your background layer selected to fix this [**Image D**]—it scales different parts of the image at different rates, so you can stretch the lower part down without affecting the upper part. If this isn't working for you, try moving the entire background to a place from which it looks good, and using "Content Aware Fill" to fill in any gaps. Select the areas that need filling, and choose "Edit → Fill." In the pop-up window, make sure "Content Aware" is selected from the drop-down, and hit "OK." Photoshop fills in the selected area with its best guess, and as long as it's something like water or sky—nothing too complex—it does a good job.

MORE LAYER STYLES

The "Layer Styles" box includes a whole lot of effects that come into their own with a clipped shape, like our skateboarder. "Stroke" puts a line around its edge; you can choose whether it's inside or outside, how big it is, what color, how it blends, and more. You can use "Pattern Overlay" to fill it with a pattern from the included set, rather than going to the trouble of finding one as an image file—with solid color and gradient options as well—or you can add a "Drop Shadow" to make it look more like the skateboarder is leaving the ground. "Satin," "Inner Shadow," and the two "Glow" options add shading to the layer that can give it a 3D appearance, while "Bevel" and "Emboss" can make it appear to be sinking into the screen.



5 DARKEN THE FOREGROUND

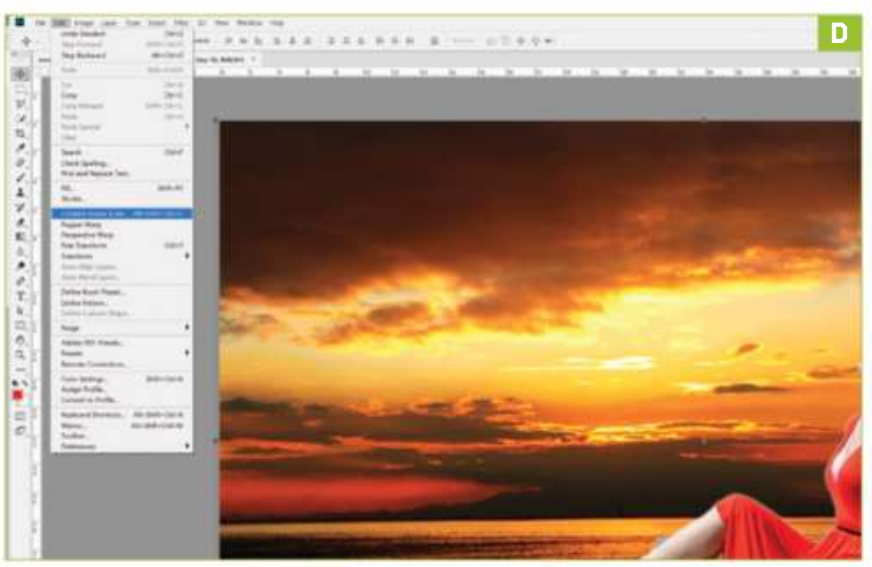
To make the full silhouette effect, select the foreground layer and open "Hue and Saturation" ("Image → Adjustments → Hue/Saturation"). Desaturate your subject by dragging the "Saturation" slider to the left, then use the "Lightness" slider to darken it by dragging to the left [**Image E**]. When happy, hit "OK."

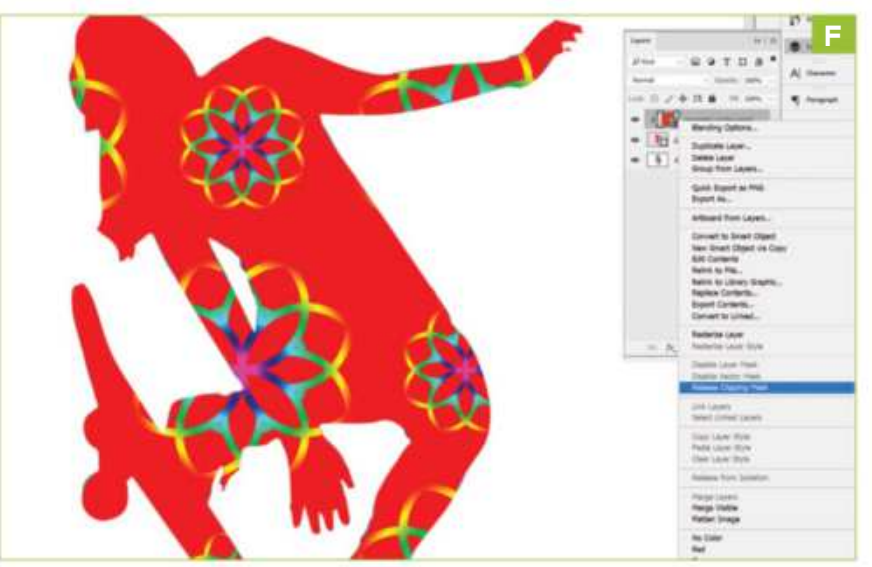
6 OTHER SILHOUETTES

Another way of creating a completely black silhouette to use as a graphic element in a composition is to make it a "Shape." Again, you need an image that's recognizable from its outline, such as the skateboarder we've chosen. You can use the "Pen" tool to trace around the outline, and this is the best thing to do if you're extracting something from a busy background. If you have a plain background, like the image we're using of a skateboarder on white, you can select the background, invert the selection, then open the "Paths" palette to create a path from the selection using the button at the bottom of the palette that looks like a circle with four drag handles on it. Whichever way you do it, decide which color you want to make your shape, and make that your foreground color. Select the "Pen" tool again, and click the button at the top of the interface marked "Shape." Your path will be filled in with the color you just chose.

7 CLIPPING MASK

Shapes exist in Photoshop as separate layers. Once you've created a silhouette, you can fill it with a pattern by importing the pattern from an image file as a new layer, and placing it on top of the silhouette. Right-click its entry in the "Layers" palette, and choose "Create Clipping Mask." The Clipping Mask [**Image F**] uses the transparency information from the layer below to tell it where the upper layer should and shouldn't be visible, so your pattern is inside the Shape you created, and nowhere else. Double-click the "Shape" layer to open the "Layer Styles" window, and use "Stroke" to add an outline.





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Gigabyte Aero 15X V8-BK4

Gigabyte's Coffee Lake Max-Q refresh

WHEN WE FIRST TESTED thin-and-light Max-Q gaming laptops last year, we had a clear favorite: Gigabyte's Aero 15X-BK4. All the Max-Q laptops we've tested scored within a few percentage points of each other, benchmarks-wise, but the Aero 15X stood apart thanks to its 5mm bezel, which allowed a 15.6-inch screen to fit in a 14-inch chassis. This made a world of difference when it came to the quality that thin-and-light laptops value most: portability.

This year, Gigabyte has updated and upgraded the Aero 15X, officially called the Aero 15X v8-BK4, with several key features—most notably Intel's new mobile Coffee Lake CPU, the Core i7-8750H. This new CPU, which will be the backbone of most gaming laptops this year, marks a huge CPU performance increase over the previous generation, mainly due to moving from four to six cores, making it one of the best gaming laptops you can buy.

The i7-8750H's extra cores show front and center in CPU-intensive benchmarks such as Cinebench R15, returning scores of 1,199 and 177 on the multicore and single-core tests respectively, up from 750 and 164 on the i7-7700HQ in last year's Aero 15X. PCMark 10 Express and 3DMark: Fire Strike both benefited from the additional computing power as well, increasing their scores by about 400 points each to 4,639 and 12,784 respectively.

Despite the better performance in CPU-intensive tasks, interestingly the updated Aero 15X performs about 5–10 percent worse than its predecessor in gaming benchmarks. *Rise of the Tomb Raider's* three-part benchmark average dropped from 94 to 80fps, while *Total War: Warhammer II* went from 57 to 54fps, and *Ghost Recon: Wildlands* fell from 45 to 41.

We're not really sure what to account the performance difference to. It's possible the new system is held back slightly by the lower per-core clock speed of the i7-8750H. The other possibility is the 2018 model has a single stick of 16GB RAM, whereas the 2017 model featured dual-channel 2x 8GB. Either way, while the performance drop is unfortunate, it's relatively negligible in the grand scheme of things—and can be recovered with a few settings tweaks—especially when you consider the upgrades to the rest of the machine.

Speaking of which, the 2018 Aero 15X fixes one of our biggest gripes with last year's system. The old model lacked anti-ghosting on the keyboard, which resulted in occasional but extremely frustrating double keypresses. The 2018 model fixes this. On another important front, the 2018 model's screen is upgraded from a 60Hz to a 144Hz display—a major improvement.

Design-wise, the chassis remains largely unchanged. It still has the same 5mm-thin bezel that allows for a 15.6-inch screen in a 14-inch chassis, although that setup is slightly less exciting now that most laptops of this generation have followed suit. On that note, the Aero 15X's primary competition is MSI's GS65 Stealth Thin and the new and updated Razer Blade. Compared to those two, the Aero 15X offers a slightly more professional look, though we prefer the GS65's metal chassis to the plastic feel and sharp edges of the Aero 15X's aluminum shell.

It's also slightly better suited for professional uses—that is, toting to meetings. The GS65's 82Wh battery lasted about four and a half hours on our streaming video battery test. The Aero 15X, on the other hand, sports a 94Wh battery that lasted upward of six hours. One other key difference is that the Aero 15X offers a 4K panel option—though we recommend sticking to the 1080p 144Hz panel if gaming is your primary concern.

All told, this makes for a compelling alternative to the GS65, if you don't mind the slightly more brutalist design. The Aero 15X is a great laptop, improving in the most important ways on our favorite gaming laptop of last year. **–Bo Moore**

VERDICT **9**

Gigabyte Aero 15X V8-BK4

LEONIDAS Impressive form factor; 144Hz screen; strong performance.

XERXES Price; slower than previous generation in game.

$2,350, www.gigabyte.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	1,199 (61%)
CrystalDisk QD32 Sequential Read (MB/s)	563	559 (-1%)
CrystalDisk QD32 Sequential Write (MB/s)	133	487 (266%)
3DMark: Fire Strike (Index)	13,202	12,784 (-3%)
Rise of the Tomb Raider (fps)	99	80 (-19%)
Total War: Warhammer II (fps)	62	54 (-13%)
Tom Clancy's Ghost Recon: Wildlands (fps)	48	41 (-15%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700 HQ, an 8GB GTX 1070, and 16GB of DDR4-2400. All game tests performed at 1080p, at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-8750H @ 3.6GHz
Graphics	Nvidia GeForce GTX 1070 8GB Max-Q
RAM	1x 16GB DDR4
Screen	15.6-inch 1080p 144Hz IPS
Primary Storage	512GB M.2 SSD
Secondary Storage	None
Keyboard	Per-key RGB backlit keyboard
Battery	Li-polymer 94.24Wh
PSU	180W
Total Weight	4.49lb

Wait, so is it Aorus or Gigabyte?

MSI Infinite X

To infinity, and... actually, no, just to infinity

REMEMBER WHEN buying a PC used to mean going to an actual store, walking around a long display of fascinating beige boxes adorned with functional jewelry, such as printers and desktop microphones, speaking to an overbearing man in a short-sleeved shirt, then waiting several days for a different man, this one less overbearing, to arrive, and put it together in your home? Modern system builders like MSI can't hope to replace the hand-drenching thrill of that 1990s experience, but they do bring a few bonuses of modernity to the table.

This Infinite X build is to those Packard Bells that came bundled with printers, scanners, and 14 Encarta discs what modern sports stars are to their pot-bellied forefathers. There's not an ounce of bloat on its spec sheet, and competition is so fierce among system builders that it's actually a conundrum to see where MSI is making its markup here. The fundamentals are checked off with muscular aplomb: a GTX 1080 Ti, Core i7-8700K, and 16GB of RAM. That's the sweet spot for high-end gaming right now, before the laws of diminishing returns really kick in and render any further performance gains pointless in the wake of escalating cost. And together, they rip through our 1080p benchmarks with predictable vigor, although for 4K gaming at a consistent 60fps, you'll need yet more firepower. MSI's own Z370M Gaming Pro AC motherboard provides the beating heart of the whole operation, while storage options ranging from SSD plus HDD to two M.2 SSDs are available in the configurator. So far, so good.

This being a high-end system, there's a fair amount of showboating going on with the case and componentry. The 1080 Ti is mounted vertically in line with side panel cutaways on the case, so you can see the 0dB fan technology in action and, like us, briefly panic that something's come loose inside and is frying your silicon. The option of a tempered glass side panel is there for those who want it, revealing a little more RGB flair. We'd hardly say our test sample was restrained, however: There's still an enormous backlit design on the front panel, and more sharp edges on the case as a whole than an Nvidia Founder's Edition blower. Shout out to the front panel full of handy ports: an HDMI for VR headsets, a USB-C for newer devices, two USB 2.0s, and one 3.0. Perhaps they could have been implemented more elegantly, but beauty is, famously, in the eye of the beholder.

We won't judge the Infinite X for dividing office opinion with its look, but there are a few case issues that go more than skin deep. The enormous power button is positioned in a hazardously easy-to-accidentally-nudge position, while the rear handle and DVD drive cover (yep, it actually has a physical media drive in 2018, go figure) feel worryingly flimsy.

Looking inside, it's clear that minor problems have reached there, too. MSI's system builders have obviously done the very best job possible to create a neat and tidy, airflow-friendly rig, but there are a few cables dragged across the motherboard and remaining in plain sight. It's a result of the case's RGB LED fanciness going on at the front, and a slightly cramped interior.

But let's be clear: All our gripes so far extend only as far as the case, and when you're talking about a GTX 1080 Ti system, that's small fry. The important thing is that performance is where we'd expect it to be, and the price is bang on the mark. With the 1180/2080 looming large on the horizon, the whole bang-for-buck paradigm is about to shift dramatically, so this isn't the ideal time to invest in a new system. However, if you're really into the Infinite X's striking look, and want to blitz games at 1080p, this is an attractive prospect. **–PHIL IWANIUK**

VERDICT **8**

MSI Infinite X

X FACTOR Blistering 1080p performance; great value.

BUZZKILL LIGHTYEAR Case has issues; soon to be outdated.

$1,799, www.msi.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	822 (-29%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	2,400 (-29%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	1,142 (-34%)
3DMark: Fire Strike (Index)	11,101	22,869 (106%)
Rise of the Tomb Raider (fps)	60	94 (57%)
Total War: Warhammer II (fps)	46	95 (107%)
Tom Clancy's Ghost Recon: Wildlands (fps)	39	71 (82%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-8700K
Graphics	Nvidia GTX 1080 Ti
RAM	16GB 2,400MHz
Motherboard	MSI Z370M Gaming Pro AC
Primary Storage	M.2 SSD
Additional Storage	2.5-inch SSD
Cooling Solution	Exclusive Silent Storm Cooling 3 PRO
PSU	550W 80 Plus Bronze (ATX)
Case	MSI Infinite X
Warranty	One year

There's a lot of muscle underneath that rather unassuming case.

VA panel technology is an odd choice for a gaming monitor.

MSI Optix MPG27CQ

A VA panel in an IPS world...

PICTURE A PC MONITOR. One with high refresh rates, low response times, snazzy styling, and RGB mood lighting. Looks a lot like a new ROG gaming monitor from Asus, right? Indeed it does, but it also describes MSI's new Optix MPG27CQ. Already a rival for Asus in other parts of the PC gaming arena, MSI is now sizing up a smackdown in the premium gaming monitor market.

The MPG27CQ arrives slap bang into the sweet spot in PC gaming monitors. It's a 27-inch panel with 1440p pixel grid. That makes for a very nice compromise between visual detail and smooth gaming. 4K gaming, after all, is a nice idea, but even the very latest and greatest graphics cards can't drive all those pixels at the triple-digit frame rates required for seriously slick and smooth gameplay. Meanwhile, if you stretch 1440p beyond 27 inches, the result is increasingly big, fat, and fugly pixels.

There are 27-inch 1440p monitors, of course, and there are 27-inch 1440p monitors. A basic model with a cheap TN panel limited to 60Hz refresh isn't exactly the stuff of gaming fantasy. Instead, what you want is something with a quality LCD panel, support for 120Hz-plus refresh, low latency, fast response times, and maybe some adaptive sync capability. What you want is something like the Optix MPG27CQ.

To the 2560x1440, 27-inch sweet spot, the MPG27CQ adds a long list of gaming-friendly features, including 144Hz refresh, 1ms response with user configurable overdrive and anti-blur, a low-input lag mode, support for AMD's FreeSync technology, and a gentle 1800R panel curvature thrown in for good measure. But that's not all. You also get some funky styling, including RGB LED mood lighting.

The net result, as we implied, is more than a little reminiscent of Asus's ROG gaming monitors, albeit without quite the same level of polish and pizzazz. But where the MPG27CQ differs from the PC gaming norm is by virtue of its LCD panel. MSI has gone for VA technology. That's not unheard of in the premium PC monitor market; VA offers significantly better colors and viewing angles compared to TN panels, and superior contrast to IPS technology. The problem is that VA doesn't exactly have a world-beating reputation when it comes to pixel response. Certainly, it isn't the obvious choice for a gaming monitor.

However, what does become clear is that the MPG27CQ is defined by its VA panel. On the upside, the colors pop and the benefits of the 3,000:1 contrast ratio are undeniable: deep blacks that even the best IPS monitors can't match. The downsides begin with the warm, oversaturated color balance that's a hallmark of most VA screens.

For gaming, that's no biggie. Access to the very last word in color accuracy hardly matters when you fire up another *Fortnite* session. More of a concern is the pixel response. MSI has fitted the MPG27CQ with a snazzy OSD menu, with lots of gaming-centric features, including user-configurable pixel response. The fastest mode introduces noticeable inverse ghosting as a consequence of what must be very aggressive pixel overdrive. It also forces on MSI's anti-blur mode, which limits the backlighting to 50 percent. While the result is improved response and reduced blurring, the costs are too high. Even the middle of the three settings comes with an inverse ghosting trade-off.

The sense is of MSI trying to hammer a square VA panel peg into a round PC gaming hole. That doesn't stop the MPG27CQ from being a nice display, but it does compromise its ability to fully deliver on its premium gaming panel remit. **–JEREMY LAIRD**

VERDICT **8**

MSI Optix MPG27CQ

SMACKDOWN Superb feature set; nice styling; bold colors and contrast.

LETDOWN Flawed pixel response; not as polished and productized as inevitable Asus competition.

$476, www.msi.com

SPECIFICATIONS

Panel Size	27 inches
Native Resolution	2560x1440
Pixel Density	109 ppi
Panel Type	VA
Maximum Refresh	144Hz
Response	1ms
Contrast	3,000:1
Display Inputs	DP 1.2, 2x HDMI 2.0
Connectivity	USB
VESA Mount	100 x 100mm
Warranty	Three years

More RGB means more money.

Asus ROG Strix X470-F Gaming

Stealth mode engaged

WHY, ASUS? WHY? We want to be kind to your products, honest we do, but with the current lack of innovation across your mid-range motherboard arsenal, it forces us into an unhappy position. Come on, you're one of the biggest motherboard manufacturers out there right now, so let's see a bit more development going on behind some of your prestigious products.

What's the problem? Well, it's a simple one, but one that makes our blood boil, and it all comes down to what can only be described as the ROG tax. Right now, the X470-F is available from Newegg for a rather pricey $212. Aesthetically, it's a pleasing AM4, ATX mobo, complete with flashy RGB heatsink, swappable chipset stickers, and a fully specced out complement of connectivity for any and all devices you might have at your disposal. That said, it really ought to be—after all, it's broken that $200 mark, and is by no means what we'd consider an affordable mobo. The problem lies with a product within Asus's own arsenal. Namely the Asus Prime X470-Pro.

Side by side, the PCB layouts are almost identical. Power phases, capacitors, traces, fan headers, SATA ports, PCIe slots—you get the picture. Even the rear I/O is the same. The two are near mirror images of each other. The only differences being the fact that the Prime lacks an additional RGB header (yeah, wow, right?), and it doesn't have quite as beefy an audio solution as the ROG. And the prices? Well, there's a sizeable $47 difference between the two—the Prime X470-Pro comes in at a far more reasonable $165.

So, why buy the ROG? That's a good question and, if we're honest, that decision mostly comes down to aesthetics. Do you like the darker styling, the rear I/O plate being pre-installed, and the I/O cover being somewhat larger than that of the Prime? If so, perhaps the ROG is the choice for you, but we're not convinced. After all, you can pick up an older X370 Crosshair VI for $12 less, and apart from the better power solution, improved audio hardware, and expanded connectivity, it also has that splendid styling. It's a far superior mobo (though, granted, you'll need to perform a BIOS update to get it to work with the latest Ryzen 2 series).

But enough railing—how does it do in our tests? Well, all in all, it's pretty darn impressive. We saw excellent scores in both Tech ARP's X264 test and the Fry Render benchmarks. Latency was far better than the other mobos we've seen so far, no doubt thanks to a newer BIOS, and CrystalDisk sequentials also performed solidly across the board, too. Unfortunately, there's still no change on the overclocking front, although we didn't expect much, and the lowest voltage we managed at 4.0GHz was 1.41V, placing it slightly worse than the Crosshair VI Hero.

Power draw is something of a problem, however, and is arguably what contributed to the high scores in both Tech ARP's X264 and Fry Render, because under load it drew 315W from the wall. That's a fairly substantial 35W more than the VI Hero and Gigabyte's Gaming 7, showing signs again of aggressive overvolting by the BIOS to encourage XFR higher.

So, all in all, if you take the price shenanigans out of the equation, it's a fairly well-rounded board. Yeah, it's a bit heavy on the old power draw, meaning you'll likely need to tweak the BIOS settings to get a nice balance between performance and temperature, but ultimately it performs well, is consistent, and admittedly (despite us criticizing it for a good three paragraphs) does look seriously good. The RGB lighting is subtle and isolated, and being able to swap out chipset stickers, although a bit gimmicky, is admittedly a neat addition.

We can't let Asus rest on its laurels, though. If you want the performance, we recommend the Prime X470-Pro; if you want the looks, you could grab the ROG, although, in all honesty, a Crosshair VI would likely serve you better. And until those marketing teams change their stance on the ROG tax as a whole (which at most should be $25, even with the additional features), we have no choice but to mark the X470-F down. **– ZAK STOREY**

MOTHERBOARD BENCHMARKS

	Asus ROG Strix X470-F Gaming	Asus Crosshair VI Hero
Tech ARP's X264 (fps)	**35.27**	33.06
Cinebench R15 Multi (Index)	1,634	**1,664**
Fry Render (m:s)	**02:33**	02:45
AIDA64 Memory Latency (ns)	**75**	96.8
CrystalDisk QD32 Sequential Read (MB/s)	**551**	540
CrystalDisk QD32 Sequential Write (MB/s)	**477**	450
Power Draw Idle/Load (Watts)	60/315	**47/278**
Total War: Warhammer II (fps)	**57**	**57**
Lowest Voltage @ 4.0GHz (Volts)	1.41	**1.40**
Maximum Overclock Achieved (GHz)	**4.0**	**4.0**

Best scores in bold. Our test bed consists of an AMD Ryzen 7 1800X, 16GB of Corsair Dominator Platinum DDR4 @ 3,200MT/s, an Nvidia GeForce GTX 1080, and a 250GB Samsung 850 Evo. *Total War: Warhammer II* was performed on the Ultra preset at 1440p.

VERDICT **7**

Asus ROG Strix X470-F Gaming

JEAN-LUC PICARD Impressive performance; strong BIOS; looks great.

ZAPP BRANNIGAN Price; power draw.

$212, www.asus.com

SPECIFICATIONS

Chipset/Socket	X470/AM4
Form Factor	ATX
Memory Support	64GB DDR4 @ 3,466MT/s
M.2/U.2 Support	2x M.2
SATA Support	6x SATA 6Gb/s
Max PCIe Support	2x PCIe 3.0 x16 (x8x8)
Rear I/O	5x USB 3.0, 2x USB 3.1 Type A, 1x USB 3.1 Type C, HDMI, DisplayPort, PS/2 port, Intel Gigabit Ethernet, 5.1 audio out, optical audio out

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HyperX Alloy Elite RGB

The ultimate desktop mashup—or a melange

ARE YOU CONSIDERING entering the cut-throat world of mechanical keyboard manufacture? Are you struggling to think of a good gimmick to set your new keyboard apart in a busy market? Follow HyperX's lead, in that case, and don't choose just one: Toss in literally every keyboard gimmick going. Make it out of heavyweight materials. Give it per-key RGB lighting, media keys, and a fancy volume roller. Chuck replaceable hot-zone key caps and a wrist rest in the box, and don't forget a dash of USB pass-through. Probably the only things HyperX hasn't included are macro keys and custom switches.

About those, then: They're standard Cherry MX switches (as much as we can call such things "standard"). Our review model came with the springy, stiff linear red variety—notchier brown and clickier blue switches are also on the table, though at the time of writing, HyperX directs you toward the older Alloy FPS if you want those. It's hard to argue with HyperX's decision to go stock on this one—while purists might sniff at the microscopically rough finish of modern Cherry switches, compared to the supposedly smoother clones coming from Gateron's labs, we're in no way offended by the feel of the red switches. They're responsive, although their actuation point is lower than some, so they're good for the sloppy-fingered, and the 45cN spring force is more than adequate; the bottom end is far from squishy, and there's a good clack to the meeting of key cap and metal shell.

The top shell goes against the name—this is no alloy; it's solid steel, giving the Elite an incredibly pleasing amount of weight. This is not a keyboard that's going to wander off midway through a gaming session, but similarly, it's not one you'll want to drag around with you. It weighs more than some laptops, and the majority of the key caps (bar braced keys, such as Space and Shift) are attached only to the plus-shaped stalks of the key switches in a particularly loose manner. That's really the only negative aspect of the Alloy Elite's construction. Its braided output, which carries a pair of USB cables for pass-through, is reassuringly thick, the media keys deep and definite, and the volume roller—non-notched, which we like, but you might not—feels amazing.

LIGHT-HEARTED

The per-key lighting, as in many cases, is forced by the switches to favor the top edge of the key, giving the numerals (in particular) only dim illumination, and although it's not hard to appreciate the frivolity of the light bar, which sits between the main keyboard and the media bar, its deep set (and perhaps our posture) rendered it completely invisible when actually typing on the keyboard. Onboard memory is a nice touch, saving your highly tweakable (and potentially zany) lighting schemes, three of which can be toggled between with a dedicated button. While there are no dedicated macro keys, HyperX's game mode is, again, just one media button away, and macro customization can be done in the driver. Who needs F-keys anyway?

Frankly, we love the Alloy Elite. Thinking critically, it has to lose a couple of virtual points because of its price—as pleasing as Cherry MX switches are, when you begin to approach the cost of super-nerd bespoke mechanical boards, stock components don't offer the same appeal. But from an emotional standpoint, while this might essentially be a slammed-together collection of the most overplayed keyboard memes, it pulls it off as a package. It's satisfying in weight and construction quality—wield it, and it would be an effective weapon. It's highly pleasing on the eye, with a bright, bold LED array. It doesn't clutter up the left edge and confuse your pinky with additional macro keys you may never use. It's highly usable, and we wager it'll last a long time. That's a heavy bias on the plus side, isn't it? **–ALEX COX**

VERDICT 9

HyperX Alloy Elite RGB

METAL Built like a tank; great lighting; excellent onboard controls.

FETTLED Loose key switches; not very wallet-friendly.

$170, www.hyperxgaming.com

SPECIFICATIONS

Switch Type	Cherry MX Red (Linear)
Form Factor	Full size (104-key)
Media Keys	Yes
Macro Keys	Programmable
LEDs	Full RGB
N-Key Rollover	Yes, with anti-ghosting
Pass-Through	USB 2.0
Dimensions	17.5 x 6.6 x 1.5 inches
Warranty	Two years

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Cooler Master CM310

Premier pointing without the wallet pounding

THERE'S A FUNNY THING about reviewing hardware: Sometimes you have to look at a device not as it is, but as it would be if it wasn't. Particularly when scrutinizing something that seems to put a lot of focus on its outward appearance, you need to imagine that thing without those features that make it what it is. Cooler Master's mouse definitely falls into that bracket, which is very handy, given the number of words we've dedicated to prattling on about such a nebulous concept. The CM310 is an utterly gorgeous ambidextrous feast of RGB lighting—but what would it be without the fireworks?

For a start, it would feel—and does in fact feel—light and a little flimsy. Yes, Cooler Master has apparently calibrated that weight to hit the 3.5oz mark, which it reckons is "the sweet spot for precision," but, eyes closed, we would struggle to tell the difference between the CM310 and a no-name $3 AliExpress special. It is, at least, molded very well, with a soft texture to the plastic and a bulbous thorax, which we feel (as much as Cooler Master might say otherwise) favors palm grip rather than claw. However, saying that, the button split in the top shell does extend further than half of the length of the mouse, and if you tend to rest your hand on top in a fist (for whatever reason—we're not asking questions), you would still be able to actuate each of the buttons by clicking far from the front.

We're sure the button switches aren't bottom-of-the-barrel cheap, but they're another aspect where the CM310 shows its price. They're bland, squashy, and light. Really, they're utterly unexciting, and easy to click by accident, at least if you're used to a sturdier mouse. The two side buttons (on the left, which makes this a touch less ambidextrous than it might have been) are similarly soft, although they are at least placed within easy reach of the average thumb, something many mouse manufacturers completely neglect to consider when balancing substance and style.

ON THE PLUS SIDE...

Without the silicon side grips—tight horizontal stripes, which feel smooth and tactile—this wouldn't be much of a mouse. And without the additional silicon in a grid spidering over the light-click notched scroll wheel (a little scratchy, but perfectly OK), it would be plain as day. But as much as we need to consider what this could be, we need to look at what it actually is. And it's one hell of a package for such little money, once you've forgiven the bits that feel cheap. It's well balanced in the hand, and the upper buttons offer quick, definite access to resolution settings, without getting in the way, and—ironically—they have the best click feel of any of the buttons on the device. And that lighting, which we so casually dismissed earlier? Darn, it's great for a device at this price. Simply fantastic. The RGB colors are brilliantly blended, there are several zones, and while you're stuck choosing between five preset modes, the CM310 is not going to struggle to blend in with any gaudily illuminated setup. It's enough to take this mouse up yet another notch, and that's before we've even considered that Cooler Master has slapped in a 1,000Hz, 1ms response Pixart A3325 sensor—one that can be dialed as high as 10,000 cpi, and easily feels as responsive as just about any other sensor on the market.

We wanted to hate the C310. We did our best, as you can tell, and we have plenty of reservations about the rough edges. But considering its price and what it can achieve, we're very impressed with the resulting package, both in terms of aesthetics and day-to-day use. Not everything has to be blowaway great; if it does the job it's meant to—and this scoots around a mouse mat as well as any other—you'll be happy, particularly if it's back-of-the-couch money cheap. **–ALEX COX**

VERDICT **7**

Cooler Master CM310

MASTER Great sensor; decent RGB lighting; comfortable shape in the hand.

DISASTER Light, flimsy feel; cheap microswitches; not quite ambidextrous.

$30, www.coolermaster.com

SPECIFICATIONS

Sensor	Pixart
Sensitivity	10,000 cpi
Sensor Model	Pixart A3325
Polling Rate	1,000Hz, 1ms
Programmable Buttons	4
LEDs	RGB (five modes)
Cable Length	6 feet
Weight	3.5oz

Corsair Spec 06 RGB

An ideal home for flashy builds—if your retinas can take it

RGB LIGHTING HAS conquered its final frontier. After invading the territory below your keyboard, the sides of your headset, and even the radiators on your mobo, this unstoppable scourge—er, trend—finally makes it to the front panel of your case. Um, thanks, Corsair.

OK, perhaps we're being a bit harsh on the Spec 06's look. And RGB lighting in its entirety, come to think of it. We're actually quite fond of that colorful flourish on the front, a swooping line of illumination, as though the case has suffered a war wound and is now bleeding pure Las Vegas Strip. And, yes, it's totally programmable and customizable, via a smartly affixed lighting controller at the rear (just below the GPU exhaust slots). Three buttons control the speed, color, and mode, of which there are seven. It's certainly convenient to have that controller on the outside of the case—not always a given.

While the RGB functionality is well implemented—and it should be noted that there's a non-RGB model available, too, if illumination's not your thing—we're much more impressed by the fundamental space and layout within the case than what's going on outside it. Although its dimensions remain reasonable enough to fit under any desk , there's an abundance of space for builders within the case once you pop off the tempered glass panel. (And it's a small point, but we're delighted to see that the rubber stays around each hole are glued in place here. These touches are what we live for.)

A compartmentalized PSU enclosure keeps the interior looking smart, and the cable feed-through cutout on the top panel of that enclosure is an especially nice touch. Keeping GPU power cables tidied away out of view just got that tiny bit easier. Meanwhile, cavernous clearances for CPU coolers and GPUs make building fairly effortless. In fact, we're fairly sure we've stayed in smaller hotel rooms than this, but this isn't a review of our poor life choices. Thank goodness.

So generous is the GPU clearance in both directions that the Carbide Spec 06 also has a couple of vertical mounting brackets for builders who really want to put their prized componentry at center stage. Doing so does mean creating quite a narrow space between the GPU fans and glass panel, but as the DIY system builders are no doubt already screaming, this doesn't seem to affect airflow or GPU core temps significantly. Not all the gear is provided if you want to orient your GPU vertically, though—you'll need to shell out for a riser cable separately, and it looks like a bit of case modding is required to actually affix it to the PSU enclosure.

If you're really worried about cooling, you could always make use of that space to fit a 360mm radiator at the front, a 240mm on the roof, and a 120mm at the rear. We've tested several other cases with similar theoretical capability for radiators this size, but few look so easy to install them in. In terms of air coolers, there's room for a total of six 120mm fans, and two are supplied. We'd say that's one additional front panel fan away from great value.

It won't come as a tremendous surprise to hear that there's room for four SSDs and two HDDs inside the Spec 06, positioned at the rear side of the motherboard mount, and again, easy to keep tidied away, along with their accompanying cables. It's a case just begging for clean lines and gaudy lights, and it makes it easy to achieve it. Yes, from certain angles the front panel protrudes too far, in order to give the fans breathing room. And yes, the finish could be better—our reset button was stuck in a depressed position, for example. But if you can live with those minor imperfections, you're rewarded with a showstopper aesthetic in wide focus. –PHIL IWANIUK

VERDICT **8**

Corsair Carbide Spec 06 RGB

SPECCED OUT Spacious; well-executed RGB.

B-SPEC Some finish issues; no PCIe riser cable.

$80, www.corsair.com

SPECIFICATIONS

Form Factor	Mid-tower
Motherboard Support	Mini-ITX, microATX, ATX
Available Colors	Black, white (non-RGB versions available in both colors)
3.5-Inch Support	2
2.5-Inch Support	4
Radiator Support	1x 360mm (front), 1x 240mm (top), 1x 120mm (rear)
Fan support	6x 120mm
Dimensions	20.6 x 11.6 x 21.1 inches
Graphics Card Clearance	14.5 inches
CPU Tower Clearance	6.7 inches
Weight	17.20lb

Thermaltake View 37

A case to show off your skills

WHERE SOME manufacturers focus on premium materials or ever-smaller form factors for their latest cases, Thermaltake has decided to pursue a different course. Boasting a windowed, gull-wing side panel that curves around to cover the top of the case, this is a chassis that's brilliant at showing off the internals of your pride and joy. Which is great if you've crafted something truly gorgeous, but how hard is it to produce such beauty? Time to find out.

The gull-wing side panel is the main selling point of this case, and its design requires some careful considerations, because you're essentially losing the side brace from the top to make way for this perspex panel. Strip the case down, and there's obvious flexing due to the shift in structural integrity. It isn't as noticeable with the side panels present, but it's still there, and has forced Thermaltake to use a corner brace to help keep the panel in place and the flexing to a minimum. It also means that it isn't the tool-free design that it was originally intended to be—you're going to need a screwdriver for the four screws that hold this brace in place.

Given there's no room for a radiator—or, indeed, any fans—in the top of the case, you'd be forgiven for thinking that this would limit the cooling options available to the View 37, but not so. There's a large space to the right of the motherboard that can take anything up to a 420mm triple-fan radiator (that's three 140mm fans), which mimics the options for the front of the chassis. And there are mounting holes for a single fan at the back of the case, along with space at the bottom in front of the PSU as well. Out of the box, you get a pair of Thermaltake's own Riing 14 LED Blue fans to keep your system cool.

Speaking of fans, you're spoiled for choice when it comes to keeping the View 37 cool. For instance, you can mount up to three 140mm fans behind the front panel, or elect to go with more standard 120mm fans instead. Thermaltake has also been keen to show off this case with a pair of 200mm RGB fans behind the front panel, which you can clearly see through that front perspex piece to great effect. If you're looking for a fully pimped-out RGB system, there's certainly a lot to like here.

The case ships with a bracket to vertically mount your graphics card, although you'll need a PCIe extender cable, which is sold separately, to actually mount your graphics card this way. If you're not using this bracket, it's easy to remove. Given the theme of this case is showing off your machine's innards, it's a shame the cable isn't included with the case, although given it's a $70 option, it's easy to see why.

We found building inside the case a particularly pleasant experience, as it has improved access compared to most other chassis. There are plenty of options for drive mounting: There are four drive mounting brackets in the rear chamber that can hold four 3.5-inch drives or eight 2.5-inch drives; and the removable drive cage in front of the PSU can hold three 3.5-inch drives as well, giving you plenty of scope for hefty storage builds. There are plenty of routing holes for your cabling, too, and even though there's no PSU shroud, we didn't have a problem keeping things tidy, due to the healthy amount of clearance in the rear section of the case.

Overall, the View 37 is worth considering for anyone who values the aesthetics of a build. It lends itself more to a custom water-cooling loop than anything else, and benefits from a swath of LED lighting, but it can produce a stunning-looking machine. It isn't perfect, the materials aren't brilliant, and it's a big ol' case, but it has buckets of potential, and for that Thermaltake should be applauded. **–ALAN DEXTER**

VERDICT **8**

Thermaltake View 37

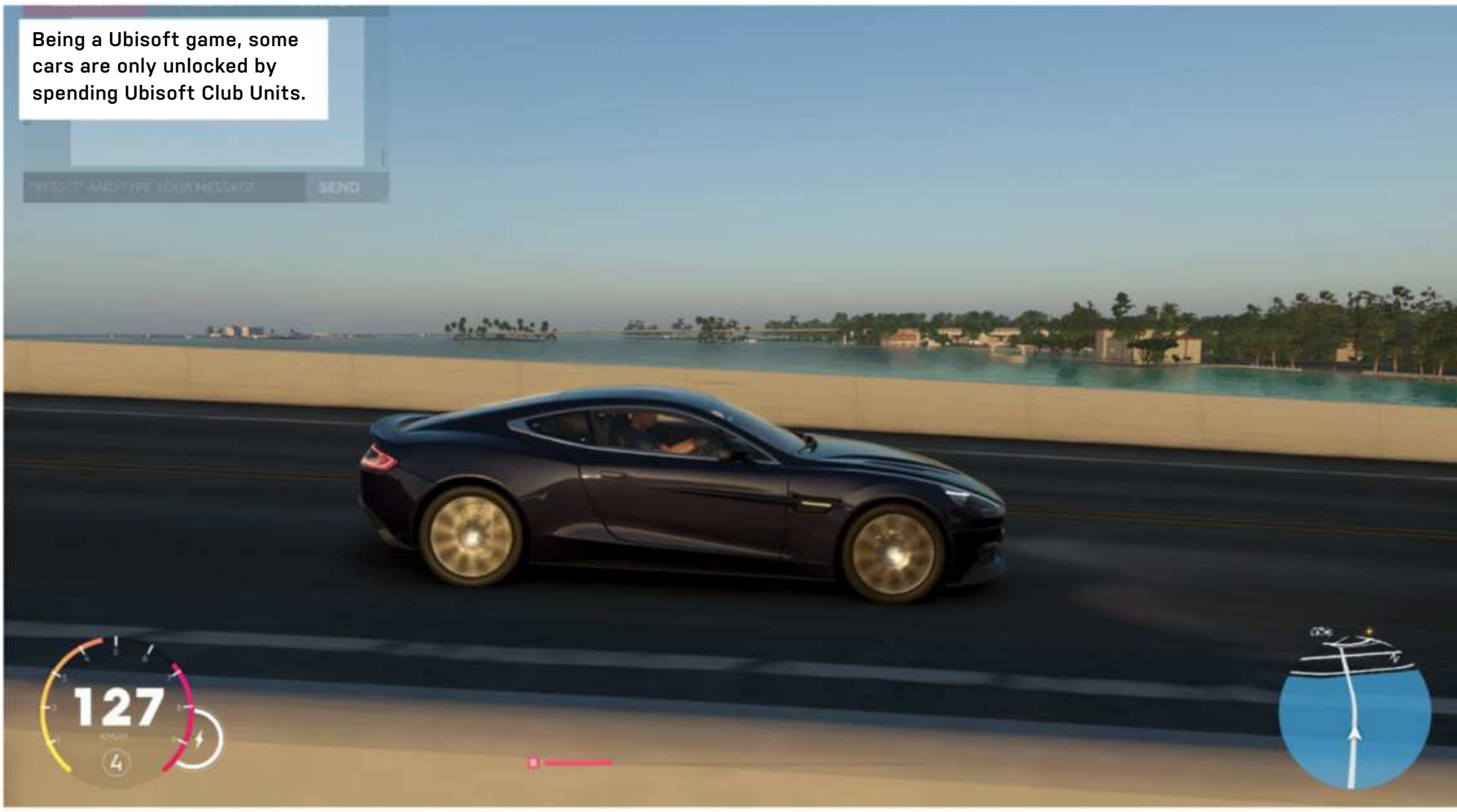
FLEXIBLE Striking looks and potential; brilliant storage options; great water-cooling options; spacious.

FLIMSY Unexciting materials; not a tool-free design, due to the brace.

$100, www.thermaltake.com

SPECIFICATIONS

Form Factor	Mid-Tower
Motherboard Support	E-ATX, ATX, mATX, Mini-ITX
Available Colors	Black
Window Available	Yes
3.5-Inch Support	3
2.5-Inch Support	8
Radiator Support	360mm front, 420mm in front of M/B tray, 120mm rear
Fan Support	3x 140mm front, 3x 140mm in front of M/B tray, 1x 140mm rear, 1x 140mm bottom
Dimensions	20.6 x 10.3 x 21.2 inches
Graphics Card Clearance	410mm
CPU Cooler Clearance	180mm
Weight	26lb



The Crew 2

Blast across the United States, and look cool doing it

AN OPEN-WORLD RACER that takes in the whole of the lower 48, *The Crew 2* is in no doubt about its size. Everything about it is tuned to be huge, to be extreme, to make you want to call people "bro."

It's not actually that huge—a drive from coast to coast takes less than an hour—but it is filled with stuff to do. Your nascent racer, looking for fame, fortune, and the opportunity to get paid for misbehaving in motor vehicles, attracts the attention of benefactors by, let's face it, coming last in the opening race, from where you head out on the hunt for more followers.

Followers are used as currency, enabling progression, as well as making you feel better about coming second by watching a number increase. It would have gone up more if you'd won, though, and this is the game's major hook. The attempt to blend a narrative into the mix of car, boat, and airplane racing is semi-successful, with veteran racers positioned as bosses to overcome, but its tone, especially the unskippable loading screens, can make you wish there was a way to turn them off.

The map is speckled with events to take part in. Sure, you could drive between them, and enjoy a greatest hits collection of US scenery, but given the size of the map, it's much quicker to click on them and fast travel. Win races and you can unlock car parts to upgrade your ride, which can greatly alter its performance and handling.

Pitched as a fun way to thrash about in expensive hardware, rather than as a simulation, *The Crew 2's* vehicles are easy enough to drive after a bit of practice. Taking your finger off the gas for a corner (there's no damage, so you can often use the old *Gran Turismo* trick of bouncing off opponents' cars), and keeping the car roughly on track toward the next waypoint marker is all that's required at the beginning. As you progress, a degree of proficiency is required, but there are so many events that you can drag out the early part of the game in which you become actually good at it for as long as you need.

City locations, despite excellent weather effects and lighting, are less impressive than the countryside, mainly as there's too much going on to distract your attention. Civilians frequently wander into the middle of a race, and as you smash them out of the way, you'll have a second to appreciate how low-res and rubbery they appear. Stores and restaurants have weird signs, offering Facial Wax Nails Massage Body Gift Shop Pizza Pizza Pizza, and it's hard to drag your attention away as you round a corner to find Breakfast & Mechanic Spa.

Another oddity, in a game about speed, is the 60fps cap. Play at that frame rate in 4K and you get an exciting experience, but racing games are ideal for the kind of frame rate heroics only PCs can provide, and it's a shame it's not implemented here.

In the absence of a *Burnout* game since *Paradise,* the open-world racer is looking for an identity. *The Crew's* mix of events, gameshow-like presentation, and steady drip of increased followers is almost there, but with a front-end out of a skateboarding video, it still has a way to go. **–IAN EVENDEN**

VERDICT 7

The Crew 2

DUDE Huge selection of cars and events; looks great; enormous map.

CRUDE No reason to drive anywhere; presentation may leave you cold.

RECOMMENDED SPECS i5-4690K/Ryzen 5 1600; 8GB RAM; GTX 1060 6GB/RX 470 8GB.

$60, http://thecrew-game.com, ESRB: T

There's no attempt to hide the hexes the maps are built on.

Claiming a hex that contains a relic grants your faction bonuses.

Imperial Guard armies have many walkers and missile launchers.

The planet is infested with numerous deadly organisms.

Warhammer 40,000: Gladius – Relics of War

The least diplomatic 4X we've ever played

THE WARHAMMER 40,000 UNIVERSE seems like a good fit for a 4X game. There's lots of traveling across dangerous distances in enormous ships, plenty of deploying troops, loads of diplomacy.... Actually, there's no diplomacy. 40K is all about the war, and filling the alien menace full of holes, so the four Xs in this game are explore, expand, exterminate, and exterminate some more.

The planet on which our four factions (Space Marines, Imperial Guard, Orks, and Necrons) find themselves is a hostile place, divided into hexagonal parcels of land. Dangerous creatures roam the landscape, which has dangerous plants, Necron tombs, and the artifacts of previous colonization attempts scattered about. Everything is out to kill you, so you hit back in the only way the setting knows: massed ranks and laser fire.

That setting is key to the game. It dictates the units, their roles, their weapons, and how much you'll like it. If you're a fan, you'll lap it up, even when it diverges from the letter of 40K lore. The four playable races are nicely differentiated, with two (Imperial Guard and Orks) being a source of massed, cheap units, while the others send out fewer, more expensive, but more individually dangerous, squads. Neatly, the two "superior" sides hit a resource limit that can see them swamped by their more numerous foes. It's a shame not to see Tyranids or Eldar, but we guess you have to save something for a sequel or DLC.

Each faction gets a storyline, played out as a series of missions. Wipe out every enemy base, and you win, so seeing a plot thread to its very end can mean keeping a vestigial nuisance faction alive for as long as it takes to complete the final mission. The AI prefers to defend than make serious attacks on your base, so it's possible to do this. The bases are your production centers for not just units but certain resources, too.

Gladius captures much of the strategy of the tabletop game, but little of its excitement. Units, even those equipped with jetpacks, react stiffly, reshuffling every time they lose a member, and somehow regenerating losses when set to heal. There's little sense of impact from heavy weapons fire, while the Imperial Guard's laser rifles seem so ineffectual, it's a marvel they kill as much as they do. The Guard makes up for it with a fun array of tanks, but the downside of fielding a large army is that the constantly repeating soundbites begin to grate.

It's a novel use of the 40K license, but for a 4X game to dump one of its tropes so completely means the favored strategy—in this case combat—must be very good indeed. With its unsatisfying AI and limp gunfire, the thrill of watching the tabletop game in motion is short-lived. **–IAN EVENDEN**

VERDICT 6

Warhammer 40,000: Gladius – Relics of War

EMPEROR Nice shake-up of the 4X; tank rushes for days; the thrill of commanding Space Marines.

HORUS Drab looks; stale AI; so much grim darkness it begins to get you down.

RECOMMENDED SPECS i5 or equivalent; 8GB RAM; GTX 660 3GB/R9 270X 4GB.

$40, www.slitherine.com, ESRB: T

LAB NOTES

ZAK STOREY, DEPUTY EDITOR

Lucid Dream Machine?

Good things come to those who wait... and wait

IT'S TIME FOR US to have a chat about that fabled prodigal son of *Maximum PC*, aka the Dream Machine. For those who don't know, every year we take the very best PC parts, and meld them together in a system that warps and pushes the very limits of our combined expertise. Each generation of Dream Machine packs more processing punch, features a bigger price tag, and often tries to break our resident master builder (this fella right here) in even more extreme and varied ways than the last.

It's a tricky task, but a mainstay annual event in the mag that we're keen to continue. That said, we have a problem, and it revolves around hardware. Last year's big-ass build featured dual Titan Xp GPUs, the 10-core, 20-thread Intel Core i9-7900X, 128GB of DDR4, and all manner of weird and wonderful storage solutions. Fast-forward 12 months, and the game hasn't really changed. We're stuck with the same GPU architectures, the same memory limitations, and very similar storage performance; the only noticeable difference would be on the processor front, going from 10-core to 18-core at most.

Where do we go from here? Unfortunately, there's no easy answer. We will definitely feature a new Dream Machine at some point, but we're waiting on the hardware. A combo of Threadripper 2 and Nvidia's latest GTX 1100-series might fit the bill, but with neither seemingly on the horizon right now, we're going to have to sit tight. Even after they launch, getting our hands on the samples, acquiring water blocks, and gathering all the hardware together could take some time. We are going to do it, hopefully before the end of this season of *Maximum PC*, but we're not quite sure when.

JARRED WALTON

Senior Editor

Have you ever had a system that just didn't seem to be working as you expected? My Z370 test bed temperatures were running far hotter than they should, and my overclocking attempts were hitting a wall. Then I installed a Core i7-8086K processor, and at stock I saw load temperatures breaking 90 C—with liquid cooling! Something was not right. Turns out the Corsair H115i was my problem. I swapped to an NZXT Kraken X61, and load temperatures dropped by 30 C. I'm still looking into the H115i to determine the root cause, but inadequate mounting pressure seems likely—or possibly just a faulty pump.

And once I'm sure the liquid cooling is working as expected, the next step will be delidding. Intel's six-core Coffee Lake processors have clearly increased the cooling requirements for mainstream platforms, and the TIM (Thermal Interface Material) is a limiting factor.

With eight-core/16-thread processors, such as the Core i9-9900K, rumored to arrive in the near future (see our news story on page 12), a good cooler is absolutely required. It also needs to be installed and mounted properly. That's why I always stress-test any new PC build, to make sure things are working as expected. Better to catch something early than run into serious issues further down the line.

Editors' Picks:
Digital Discoveries

Bo Moore, hardware lead, and Alan Dexter, executive editor, share their latest tech passions

NZXT S340 ELITE

I have to gush for a minute about the NZXT S340. I know it's not exactly a new case, and its goodness is already well documented, but recently I actually built a new PC inside one, and I finally understand the hype.

It's been a while since I fully built a new rig for myself. The last time I did was long before I started working at *Maximum PC,* and at the time my hardware knowledge was much more limited. The build worked fine and all, but I shudder to think how bad my cable management was back then. (To give you an idea, a few years later, the PC started chugging every time I booted up a game. At first I thought it was the semi-outdated graphics card, but it turns out my CPU fan was getting tangled in a stray cable, and thus wasn't spinning. See what I mean?)

Fast-forward to this S340 build, and I'm in awe at how easy cable management is, from conveniently placed slots in the PSU shroud to handy cable clamps on the backside to help with cable management. I'm no expert builder, but I'm proud of how good my finished build looks, and I know this case helped me get there.

$100, www.nzxt.com

MAGIC THE GATHERING: ARENA

Magic the Gathering has had a turbulent history with PCs—the Microprose classic was great fun, but very limited; while *Magic Online* has the core mechanics (mostly) sorted, albeit in an interface that is about as appealing as a double-entry ledger. This latest attempt at porting what is a brilliant game to the PC deserves to be more successful though, for all the right reasons.

Currently in beta, *Magic Arena* looks like a modern streamer-friendly game, plays smoothly, and, bugs aside, contains all the latest cards. Importantly, it manages to capture the deep complexity of a game that has been around for 25 years, without bogging you down in its more intricate cleverness. It has a modern pricing mode, too, so you can play for free, completing quests to unlock in-game currencies and packs, though you can create more powerful decks much quicker if you throw cash at it.

It isn't perfect—deck creation is frustrating, and some of the interface design choices aren't initially obvious (you'll definitely lose games due to misclicking)—but it's a significant leap forward. It manages to scratch that itch that *Hearthstone* can't quite reach, at the very least.

Free, http://magic.wizards.com

GEEK TESTED & APPROVED

Logitech Craft Wireless Keyboard

A KEYBOARD for creative people is the pitch, despite the fact people have been creative with PCs for decades using a standard 104-key model. What it means in practice is a really nice wireless keyboard with a dial in the top-left.

It's good and heavy, not exactly portable, but not designed as that, and uses Logi's Unifying Receiver. The keys are on scissor switches, but have a decent amount of travel and sense your hands, so they light up when you need them to. They're concave, so your fingertip fits into a depression in their surface. It's really good to type on.

The major gimmick is the dial, or Crown, which can be programed for different apps. For Photoshop's Brush tool, it changes the size of the tip, a tap on its edge bumping across an on-screen overlay to change Hardness, Opacity, and Flow. With other tools selected, it zooms, adjusts brightness, and more. Select a cell in Excel, and the Crown zooms and scrolls, but select several, and it creates charts and tables, then changes their colors and styles. Select text in Word, and it changes the font size or alignment; choose an image, and you can scale and rotate it. In web browsers, it flips between tabs.

That last one might get lots of use, because using the Craft is, at first, a memory test. You'll get used to it, will miss it when it's gone, and it certainly beats holding down a function key and rolling the mouse wheel. **–IE**

$200, www.logitech.com/craft

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Motherboard Woes
> SSD Upgrades
> Backup Perfection

BIOS Bother

Your reply to "Buyer Beware" (August 2018) about buying all the components at one time does not fix real-life problems. I bought an Asus B350 motherboard and an AMD Ryzen 5-2400G within a week of each other. To make a very long story shorter, after building the system, I had no video. After calls to Asus support, I was told that the motherboard had an outdated BIOS and had to be shipped back to them for a BIOS flash update. Great. They wanted me to ship the board back at my expense, they would update their outdated BIOS, and ship back to me. I pay for the shipping to them, wait a week or more, and then might have a working system. They refused to pre-ship me an updated motherboard (at their expense—I was willing to have a hold placed on my credit card until returned), explaining their policy to me about updates.

I intend to return the Asus board, and buy from a reliable company that might have true customer support. So, problems do exist even if all the components are purchased together.

–Jeff Goodstein

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: That's a really unfortunate turn of events, and you have our sympathies. There's a chance this sort of thing can happen when resellers have stock that then needs updating to take into account new chips, particularly when those processors are APUs, and you need access to the integrated graphics.

One option you do have (if you haven't already returned the board) is to pop a graphics card into the motherboard and update the BIOS yourself, although this requires a spare graphics card to achieve. Even still, it's a shame that Asus couldn't have been a bit more flexible with sorting out the problem for you.

Drive Time

I read your August article on the Samsung 970 Pro 512GB M.2 SSD. The article indicates a PCIe 3.0 x4 interface is needed, and that the NVMe control protocol is required. My computer is a 2011 HP Pavilion PC p7-1067c, which has PCIe interface slots, and I am running the latest version of Win 10. Will the Samsung SSD work on my computer, or is the PCIe interface too old? **–George Clendenin**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: The first specification for the NVMe protocol was finished the year you bought your machine, but the first hardware to support the standard didn't start shipping until 2013, and consumer options surfaced even later. So, unfortunately, your machine is too old, and doesn't have the necessary protocol support to use the drive.

You also need to physically connect the drive, which isn't as straightforward as you might think—you can't simply plug it into a PCIe slot; it needs to be an M.2 connector. While there is a PCIe mini card connector on your motherboard, it isn't compatible. At the time these motherboards were produced, the main focus of these slots was for updating the wireless capabilities of the machine, not for adding super-fast storage.

Essentially, then, if you want to experience the joys of a quality NVMe M.2 SSD, you're going to have to upgrade your machine. Given your machine is seven years old, you could maybe treat yourself to something a bit newer and faster—unless, of course, it does everything you want

↘ submit your questions to: comments@maximumpc.com

already, in which case, such an upgrade isn't necessary.

Fit for Purpose?

Just wanted to mention that CloneApp, while promising, is not really ready for prime time. Although it is up to version 2, it is so buggy and missing features that it should be a 0.9 beta. Did anyone fully check that out before suggesting it?

–Salvatore Fattoross

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: While we admit that CloneApp may not be able to do everything you could want from a backup tool, and indeed only supports a limited number of applications (roughly 250), the fact that it's free offsets this a little. If you don't have a lot of applications installed, then it could be all you need. Obviously, if you have a lot more installed, then chances are it's going to struggle. But yes, we did test it beforehand.

Backup Advice

For off-site backup, we recommend Carbonite for our business customers. We recently recovered 25 computers, with associated design and drawing data, for a manufacturing company whose main office building burned. Successfully, because the company was using Carbonite. Why was there no mention of this excellent product in your recent article? It has suitable offerings for individuals up to and including larger companies.

We do agree with the good words about Syncback, our regular recommendation for individuals. **–Clare Zickuhr**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Carbonite is indeed a great option for business (and speaking to our IT guys, Veeam is also a worthy contender), and while we didn't mention it in the article in question, that doesn't mean that we don't rate it, or recommend it. It's purely a case of trying to cover the most relevant option for our readers. The problem with backup software is that there are now so many options, with so many specific uses, that it's difficult to recommend something that will appeal to everyone.

Poppin' Tags

I was very pleased to see the "Bargain Hunting" article in the July issue. I did that very thing with this machine back in 2010. It's an HP/Compaq 5320f, which came with a dual-core 2.8GHz Athlon II, 3GB of RAM, and onboard Nvidia 6150se graphics.

I'm a Linux user whose only system-intensive application is *Second Life*, so it worked fairly well for me. (I have the PS3/PS4 for any gaming.) Then, as the years went on, I upgraded it bit by bit.

I first slapped an EVGA GT220 in there in 2011, then a GT640rev2 SC 1GB GDDR5 in late 2013, alongside a Cooler Master 550W power supply. In 2014, I maxed out the RAM (I thought) to 4GB, and then upgraded the CPU to a quad-core Phenom II 925. Last year, I discovered that the mobo does support more than 4GB (someone reported that it could handle 8GB), so I upped it to 8GB of Kingston FuryX, and upgraded the video card to an EVGA GTX 1050 TI SC 4GB. Last week, I decided to take a chance and see if the mobo could handle 2x 8GB SIMMs, so ordered me up some Kingston ValueRAM, installed them yesterday, and they're fine.

I can't really upgrade the CPU and RAM any further, and the CPU is probably the weak point now, so I was thinking about doing a system upgrade next year by finding some bland office refurb box with a nice CPU, and doing the same thing I had been doing. And lo and behold, your article shows up with some great pointers. Thanks! **–Ron Rogers Jr.**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Glad you enjoyed the article. We're planning on revisiting this idea later in the year with a couple of machines, to see what sort of magic we can weave on the tightest of shoestring budgets.

Routing for You

In the July issue's letters, you requested input as to desires for router reviews. I would appreciate a comparison of router security support policy. That is, how long will vendors continue to support devices with firmware security updates? I'd like to see a stated policy guarantee.

I have a Linksys router that is a subject of VPNfilter malware. It is a model still available at retail. Linksys states it is end-of-life, and does not appear to be planning a firmware update.

I would also appreciate a VPNfilter article that is more explicit as to the stage1attack vector. After a reset to defaults and a change of password, is the device safe, or is a firmware change mandatory (making my Linksys device obsolete)? Also, if a router offers a settings backup/restore, is it safe if defending against VPNfilter? **–Jon Roling**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Hopefully, this month's deep dive into the technology powering Wi-Fi will sate your hunger a little, until our router roundup appears. We'll be taking a look at the growing problem of router security in a future issue, as well.

Personal Backup

Excellent article on "Perfect Backups," providing info that's very good to know and think about now and then. I'm sharing my method, suggested product (I am a long-time satisfied user, nothing else), and question. I use a Windows 10 Home x64 Dell PC, with 1TB SSD, and two HDDs (2TB each; different manufacturers, to ensure failures don't happen together, hopefully).

Typical OS and programs on C, user data on D, second HDD F (WD Black) as backup to C and D, and USB HDD (6TB) as remote backup (only connected when backing up, and stored elsewhere).

I use and recommend a backup program called Second Copy. It's low cost, and has worked for me since Win XP, through Win 7, and now Win 10. I'm now using Second Copy version 9. The author is very responsive to bug fixes (very few; none critical). I've been doing this for over 10 years, have had no problems, and very few recoveries have been needed so far.

My method is to use Second Copy to back up C and D data automatically to F on a scheduled basis, with control over how, when, what, and where from/to. I can manually run any profile as needed from the taskbar.

For any critical work, I might simply manually copy files to the F drive and/or the USB HDD.

I back up the OS image et al using Win 7 Backup and Restore, and the F drive to the USB HDD two to four times a year, depending on the importance of data. I store the USB HDD offsite.

This approach works for me. Do you see any potential flaws I should consider changing? Feel free to share my concept with magazine subscribers. **–Doug Schafer**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: The thing about any backup regime is that you need to trust what you do and actually use it, and given you've been doing this for 10 years, you've obviously got a system that works and that you're happy with. We wouldn't change a thing for that reason alone.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$50
PSU	450W Corsair CX450	$45
Mobo	ASRock AB320M-HDV	$50
CPU	AMD Ryzen 5 2400G	$160
GPU	N/A	$0
RAM	8GB (2x 4GB) Team T-Force Dark @ 3,000MT/s	$80
SSD	120GB Kingston A400 120GB 2.5 SSD	$35
HDD	1TB Seagate Desktop ST1000DM003	$37
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$16

Approximate Price: $473

HAVE A QUICK LOOK at the parts list above, and you'll notice a complete lack of red "new" flashes. That's because this machine is exactly the same as the one we built last issue, bar one subtle difference: It's $1 cheaper. This is due to the BitFenix Nova GT case seeing its price drop by that amount. We did look at tweaking some of the components, but to be honest, this machine does what it sets out to do so brilliantly that shifting from this specification would either see the price rise dramatically, or the performance take an unnecessary tumble in order to save just a few dollars. Taking the RAM as an example, we could have saved $5 by dropping down to DDR4-2400 memory (there were plenty of kits at this price from a range of manufacturers), but that would have hurt performance significantly, and we ultimately deemed that a false economy. So, as of right now, there are no changes to our budget build. This is currently as good as it gets.

MID-RANGE

INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$81
PSU	550W EVGA SuperNOVA 550 G3 80+ Gold		$80
Mobo	Asus ROG Strix B450-F Gaming	NEW	$130
CPU	AMD Ryzen 5 2600	NEW	$170
Cooler	Be Quiet! Dark Rock 4		$75
GPU	EVGA GeForce GTX 1060 Gaming 3GB	NEW	$230
RAM	16GB (2x 8GB) G.Skill Aegis 2,800MT/s	NEW	$144
SSD	250GB Samsung 970 Evo M.2 PCIe SSD		$108
HDD	Hitachi Deskstar E7K1000 1TB 7,200rpm		$37
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $1,155

THERE ARE PLENTY of changes for our mid-range build, brought on by a price hike on the Intel Core i5-8400 that we've used previously. A $20 increase may not seem like much, but it was enough to force our gaze over to AMD's second-gen Ryzen chips. Of these, the six-core Ryzen 5 2600 is the stand-out value option. With its 3.4GHz base clock and 3.9GHz Max Boost, you get a lot of performance for a lot less than the Intel alternative. A processor switch means a new motherboard, and we were more than happy to pick up the Asus ROG Strix B450-F Gaming. This is a great mobo, with plenty of quality features, including high-definition audio and twin M.2 sockets, for just $130. As Ryzen benefits from faster RAM, we picked up a 16GB kit of G.Skill Aegis RAM that operates at 2,800MT/s. The final change was on the graphics front, with the EVGA GeForce GTX 1060 saving another $10 over last month's card, and you get a copy of *Destiny 2* for free as well.

UPGRADE OF THE MONTH

AMD RYZEN 5 2600

We sang the praises of the second-gen Ryzen 5 2600 when it was first released, but time has only improved the lot of this mainstream chip. The big news is that, since launch, the price has dropped by $30, making it an incredibly tempting option compared to Intel's Core i5-8400, which rolls in at $200. It's true that Intel's chip still has a slight edge in gaming, so if that's your main focus, by all means stick with Team Blue, but for more general usage, AMD's chip can deliver just as well.

Like Intel's offering, the Ryzen 5 2600 has six physical cores, but unlike the Core i5, it has multithreading turned on, which means you get 12 threads to play around with, which makes a big difference in those apps that can use the extra threads. It also comes with the very capable Stealth cooler, so if you're looking to keep costs down, you don't need a third-party cooler either. It's unlocked as well, so you could push it harder than the 3.9GHz Max Boost if you do up your cooling game.

$170, www.amd.com

TRY THIS ON FOR SIZE: Do not buy this machine. Seriously, we're on the cusp of brand new hardware releases, and by the time you read this, AMD's latest second-gen Threadripper (filled with delicious Ryzen 2 architectural goodness) and Nvidia's GTX 1100 series (with 4K killing gaming cards) should be available. So, this build will be approaching the realms of obsoletism. Unfortunately, we haven't had chance to get hands-on with either of them yet, so can't recommend them until likely next issue, when you can expect all of this to change quite dramatically.

This does give us an opportunity to take another look at where we're at, however. Our Intel build is fairly well balanced. It doesn't have the balls-to-the-wall multicore performance of Threadripper, but its single-core prowess rounds out a competitive solution, especially for those in the professional gaming arena. We're not talking esports athletes, but streamers and content creators. Intel's single-die architecture is still very well optimized for most AAA titles. Couple that with 10 cores pumping out a chunky 4.3GHz, and you've got enough throughput to stream and game at high quality on the same rig.

Within the next month, we'll likely see AMD retake that title, offering more cores for less money at an even higher clock speed, and really cementing itself into that pro-gaming, media creation outlet with its X series, and then the WX series being more useful for the small-scale CAD CAM developers. But until then, just hold fire.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	NZXT H700i	$180
PSU	Corsair RM750X Modular Gold	$110
Mobo	ASRock X299 Extreme4	$190
CPU	Intel Core i9-7900X	$895
Cooler	Corsair Hydro H150i Pro 360mm AIO	$160
GPU	MSI GeForce GTX 1080 Ti ARMOR 11GB **NEW**	$650
RAM	32GB (4x 8GB) Corsair Vengeance LED 2666	$330
SSD	512GB Samsung 970 Pro M.2 NVMe	$230
HDD	2x 2TB Seagate BarraCuda ST2000DM006	$130
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$2,975**

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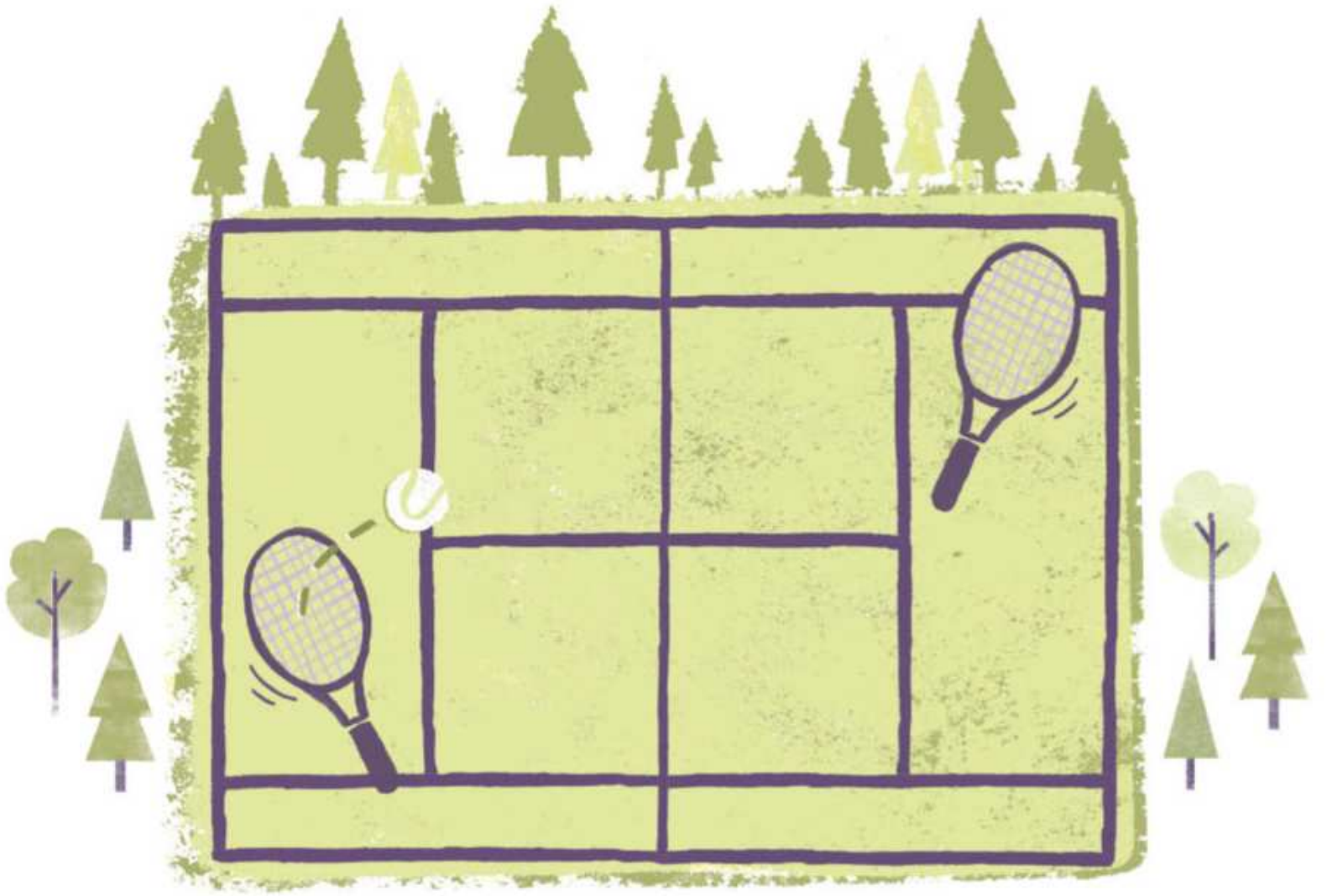

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